How the SOLAR POWER TOWER works . . .

# SILICON CHIP

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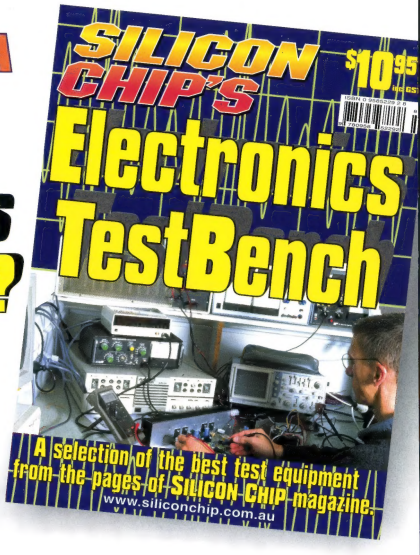


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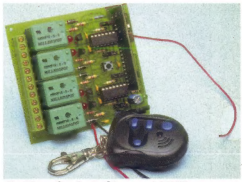

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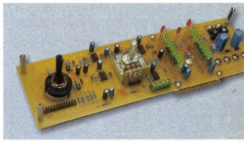

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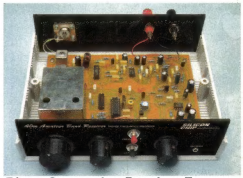

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# PUBLISHER'S LETTER

## Is our electricity too cheap for solar to succeed?

Our feature article on solar power in the March 2002 issue certainly stirred up a lot of interest. We are still getting letters on the subject. Some people have strongly disagreed with the article while others have generally agreed while taking issue with our stance on the Greenhouse effect.

Funnily enough, quite a few people cannot appreciate or totally discount the concept of "payback period" for a substantial investment in solar panels. They equate it with any other household purchase. We don't go along with this at all since, apart from a general warm fuzzy feeling about "doing the right thing by the environment", solar panels don't actually increase your comfort level in everyday living and they certainly don't have a big payback, no matter how you do the sums.

Since we are of this opinion, people then automatically assume that not only are we against the concept of installing solar cells but we are such "rednecks" that we don't care about the environment. Nothing could be further from the truth. I have written many editorials about energy wastage over the years and I still think that we as a nation are very wasteful in our use of energy and raw materials.

The real problem concerning solar cells is that in general, our electricity prices are too cheap, and this applies particularly to domestic off-peak hot-water rates. It is this cheapness of electricity which results in such long payback periods for solar cell installations in metropolitan areas.

There is another way of looking at the relative cost of our electricity. Just compare your quarterly bills for electricity and telephone, including your mobile. When you get right down to it, no-one would argue that telephones are more important to everyday comfort and welfare than electricity. Just think of winter heating, electric blankets, hot showers in the mornings, ease of cooking, refrigeration and all those other benefits which come as a result of having a reliable electricity supply and which we take for granted.

Yet I'll wager that virtually everyone who reads this editorial pays far more for their telephone services than they do for electricity. Consider also the enormous investment and infrastructure we have in producing electricity, compared with that for telephones. Looked at in this way, surely electricity is relatively very cheap while phones and mobiles are far too expensive.

Until solar panels become a lot cheaper or electricity rates go up quite a lot, solar panels will not be a practical investment for more homes in metropolitan areas of Australia.

**Leo Simpson**

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# MAILBAG

### Temperature limits for solar pump controller

I was interested in the article about a pump controller for a solar hot water system by John Clarke which appeared in the March 2002 issue of SILICON CHIP. I don't know why anyone would want to build this unless he built his own system from scratch, because I would have thought commercially available systems would have their own controller built in. However, being a 'dabbler' from way back I can certainly appreciate why there would be an interest in this type of thing.

I thought you may like to hear of my own experience with a system similar to this. About 18 years ago, I bought a house (in country Queensland) which was already fitted with a solar hot water system manufactured by Rheem. Because this system had the storage tank situated in the laundry and the solar collectors up on the roof at a higher level, it had a built-in pump to circulate the water.

After I had moved into the house, in the dark and early hours one morning when I had risen to answer a call of nature, I noticed that the HWS circulating pump was running. (The pump motor was actually very quiet in its operation but in the dead of night it could just be heard). To me, this had to be nonsense and the HWS must be defective! After all, the Sun was around the other side of the globe somewhere, so how could this possibly be?

When I contacted the Rheem people to find out what may be happening, they asked me what the outside air temperature was at the time. At that stage, I could not answer the question but he informed me that if the outside air temperature fell below a certain figure (I think it was 4°C), the controller was designed to start the pump to circulate the water in the collectors to prevent them freezing.

The next night, I put a thermometer up on the roof and although the weather was not cold and the nights were a little cool, I was surprised to find that the roof temperature went down to 0°C and the circulating pump was running.

I found that, in operation, the HWS pump started when one of these conditions existed:

(1). The temperature difference between the roof panels and the storage tank exceeded a certain amount. (I don't remember the figure, but it was stamped on the pump controller itself. This was for the normal water heating operation);

(2). The roof panel temperature fell below 4°C (to prevent the collectors freezing up and subsequently being damaged);

(3). The storage tank temperature rose above a certain figure (I think it was 75°C and I think this was to limit the temperature reached by the water in the storage tank).

All in all, it shows that there are often a few more factors which have to considered by the designers of devices such as these than may at first be realised.

**Alan Adam,**
**Bald Hills, Qld.**

### Environmental politics: does it add up?

Firstly, I would like to state that I agree that solar power and in particular, solar panels, are still quite a distance from becoming mainstream and the sums don't always add up for a successful installation. However, I was concerned by Ross Tester's extreme bias against solar power and lack of research for his article "Solar Power for All" in the March 2002 issue.

This was evident from statements such as "Why not make a solar panel which IS the roof cladding". Roof integrated solar tiles have been around for quite a while, along with solar panel skylights and windows. Check out the Australian publication ReNew by the Alternative Technology Association and their website at **www.ata.org.au**

Perhaps in future you could do an article that explains the technology behind solar panels and even about the plants in Australia that produce them. One is gearing up near Canberra to build translucent solar panels based on a new technology where the solar panel cell is created using a titania ($TiO_2$) substrate. Apparently a rise in temperature actually increases the efficiency of the panel slightly, unlike older technologies. See their website at **www.sta.com.au**

You could also add purchasing "green" power to your "Better Ways To Save Greenhouse Gases List" – this has to be an obvious choice for making a difference, particularly with the recent deregulation and publicity about the power industry. Also I could not understand Leo Simpson's argument for being completely off the grid. Are our infrequent power outages enough to justify the much greater cost of such a system? There is the added downside of greater maintenance costs due to the required batteries.

**Wayne Bowers,**
**via email.**

### Greenhouse effect is real

I would like to firstly commend you for the article on solar power in the March 2002 issue of SILICON CHIP. It gives a clear assessment of the current state of economics of domestic use of solar power. I also liked the inset panel on other ways to reduce energy usage.

However, Ross Tester is on less firm ground with his dismissal of the significance of the Greenhouse effect. He has confused two separate elements. The basic physics of radiative interaction between trace atmospheric gases such as carbon dioxide, methane, nitrous oxide and water vapour and the long-wave emission of energy to space is well established. The fact that these

gases have absorption spectra in the long-wave part of the radiation spectrum gives them an important role in the Earth's energy balance.

This has been known for over 100 years. The so-called natural Greenhouse effect has kept global temperatures some 30°C warmer than without those gases.

Where most of the controversy arises is how the ocean/atmosphere system will respond when concentrations of some or all of those radiatively-active gases change over time. We know from ice cores in Antarctica that both global temperature, carbon dioxide and methane levels tend to vary in phase – that is, higher temperatures tend to coincide with higher levels of carbon dioxide and methane, and vice versa. This has happened over millennia with the cycle of ice ages and interglacial periods.

So climate change is entirely natural. It occurs on shorter time scales (decades and centuries) as well as on longer time scales. Knowing this background and the sensitivity of the global climate system to trace gases, it is reasonable to expect some impact if concentrations of these gases increase rapidly. They are being given a big nudge. We are conducting a global experiment with the atmosphere that cannot be stopped.

Ross Tester has mixed up the controversy of just how the atmosphere will respond to the changed composition with the underlying theory. Most of the arguments come from how well global climate models can firstly simulate current climate and secondly simulate future climate. They tend to get the big picture right but are less satisfactory at the details, such as regional effects and simulating rainfall.

Thanks also for the excellent article on remote sensing. It also has a good summary of issues relevant to climate change.

**Ian Foster, Research Officer,**
**Department of Agriculture,**
**South Perth, WA.**

## Solar power can be cost effective

I have a number of comments on the article on solar power in the March 2002 issue. Mr Tester makes statements about greenhouse emissions and global climatic change based more on opinion than much scientific research. The debate about greenhouse modelling will be ongoing for years and is beyond the scope of this letter but references to the "Leipzig Declaration" are trivial. At best the declaration is controversial and many regard it largely as propaganda promoted by energy producing companies and countries. It is worth looking at **www.naturalscience.com/ns/letters/ns_let08.html** for a more comprehensive perspective.

Mr Tester correctly notes that few installations would be net energy producers but this is rarely the intention – domestic grid interactive systems are designed to reduce electrical consumption. The fact that energy is available only during daylight is of little consequence, besides which daytime peak loads are responsible for load shedding (blackouts) by power companies. Battery storage is necessary in rural areas where the grid connection is not available but would be too costly and require ongoing maintenance for most users. The grid can be considered as a "battery" delivering power when solar is not available and is an elegant and practical solution to energy "storage".

Sydney's annual 1500kWh/kW of solar energy would be based on an average of four peak sun hours (PSH) per day delivered by PV panel (1000W x 4PSH x 365 days = 1.46MHh). As the panel is supplying this energy, its inefficiencies including installation parameters are already factored in – 95% derating is not relevant. Computer modelling for a 1kW PV panel at Sydney's latitude returns figures of around 1.5-1.7MWh per annum which is in keeping with the stated claims.

PV panels are between 10-14% efficient in converting total solar insolation to electrical energy and are limited to the solar radiation spectrum as much as cell design. A theoretical maximum of around 25% applies.

The term "payback period" is nonsensical. If we apply it to other electrical appliances, the period is infinite yet we purchase any number of these without too much thought to efficiency. Payback periods are not true representations of the application – it

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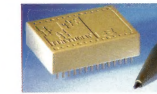
**The Tiger comes to Australia**



**The BASIC, Tiny and Economy Tigers are sold in Australia by JED, with W98/NT software and local single board systems.**

Tigers are modules running true compiled multi-tasking BASIC in a 16/32 bit core, with typically 512K bytes of FLASH (program and data) memory and 32/128/512 K bytes of RAM. The **Tiny Tiger** has four, 10 bit analog ins, lots of digital I/O, two UARTs, SPI, $I^2C$, 1-wire, RTC and has low cost W98/NT compile, debug and download software.

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## Mailbag: continued from page 5

is investment and must be considered as such.

Consider the $11,000 (after rebates) system installed as described in Mr Tester article. The after-rebate cost would be typical for a 1.5kW system generating about 2.2MWh per annum. Based on our electricity costs of 15.5c/kWh (I am not certain where Mr Tester buys electricity at 9.8c), the annual return would be about $330, or about a 3% return on investment, tax-free.

The figures for appliances quoted in reference to the 450W system are dubious. Our actual figures are as shown in Table 1 below.

The 450W system delivers 675kWh annually (0.450 x 1500kWh). If equipment is used efficiently, and with appropriate lighting, the claims by Pacific Solar are reasonable.

Note that three of these appliances are phantom loads and could add up to another 500Wh per day (182kWh/annum) – a good argument for turning them off at the wall, at least overnight.

Without a comprehensive energy audit and site assessment, we never recommend a PV or any other renewable energy system, but sized correctly and with energy efficient appliances, good building design and proper financial practices rather than guesswork, they can be cost effective and environmentally sustainable.

**Roland Denholm,**
**Powercom Solutions,**
**North Ringwood, Vic.**

*Comment: the current Energy Australia electricity rate for domestic consumers (Sydney) is 10.318 cents/kWh. Regardless of whether you regard payback period as relevant or not, a 2% or 3% after-tax return on investment is poor.*

### Washing circuit boards does work

I had to smile at the Serviceman's story in the March 2002 issue, where he took soap and water to the innards of a television set. Every serviceman knows that water and electronics means disaster but confession is good for the soul and so back in the 1980s I used to throw populated circuit boards into a tub of warm soapy water and scrub them with a small scrubbing brush! I never once had a failure.

The boards that got washed were computer keyboards that had been "christened" by the customer at smoko times by coffee, lemonade, creamcakes, etc. In those days, the keyboards were expensive and it was worthwhile spending the time to remove and put back 80-odd big chunky keys which strangely enough, never seemed to suffer any damage themselves from liquid ingress.

It was no good simply squirting the board with those products that servicemen know and love so well. The gunk just stayed there, taunting you! Coffee and lemonade spillage only came off with water and the soap and scrubbing ensured that none was left to continue electrical leakage between board tracks or IC pins.

The board also had to be totally immersed in the warm soapy water and moved back and forth to ensure that all the stuff was washed out from the tiny gaps between the silicon chips and the board where the brush couldn't reach. Then the process was repeated in fresh water to rinse off the soap.

Finally, (because it was only fresh water which is an insulator), the board got a good blasting under the water tap, just to be sure.

I used two methods of drying the boards. The old formulations of contact cleaner in a spray can touted as "leaving no residue" were ideal for blasting water out from under the chips. The stuff might have damaged the ozone layer back then but it had an enormous affinity for water, evaporated rapidly and left those narrow places where water could stay trapped bone dry.

The whole board was then placed somewhere static-safe where it would stay at a hot-but-touchable temperature (blazing sun, central heating, bench lamps, etc) for several hours after it was observed to be totally dry. Such was the low-level "scientific" approach to the drying process!

I did not coat the boards with a protectant advisedly. It was about that time that AWA issued a service bulletin to its agents that the specific product CRC 2-26 should NOT be sprayed on circuit boards to "protect" them from the environment.

I hasten to say that CRC 2-26 is an excellent product and one of its strong selling points is that it can soak in to every tiny nook and cranny and keep moisture out. But it was so good at its job 25 years ago that AWA warned in the 1970s that any electrolytic capacitor coated with CRC 2-26 was likely to suffer premature failure. The assumption was that the product was leaching inside the electrolytic via the legs and somehow ruining the chemical action so fundamental to these capacitors. I wonder if the situation is the same these days?

I can't leave without letting Rodney Champness know that he shouldn't try to "protect" any vintage selenium plate rectifiers he might find with CRC 2-26. It wrecks the forward-reverse resistance ratio over a matter of weeks or months and they stop being rectifiers.

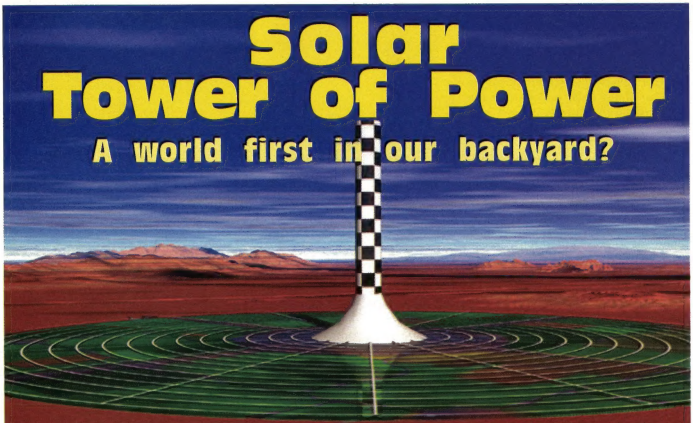
**Stan Hood,**
**Christchurch, NZ.**

**Table 1: Appliance Loads**

| Appliance | Load | Hours/day | W.h/day | kWh/a | Comments |
|---|---|---|---|---|---|
| Microwave | 680W | 0.2 | 136 | 50 | Phantom Load |
| TV Set (68cm) | 116W | 5 | 580 | 211 | Phantom Load |
| VCR | 15W | 5 | 75 | 27 | Phantom Load |
| Toaster | 900W | 0.2 | 180 | 65 | 12 minutes/day max. |
| Lighting | 210W | 5 | 1050 | 383 | 2 x 15W + 3 x 60W globes |
| Load Total | | | | 736 | |
| PV System | | | | 675 | |
| Shortfall | | | | -61 | |

# Solar Tower of Power

## A world first in our backyard?



*Solar Energy. Wind Power. These are some of the phrases which spring to mind when environmentally-sensitive generation methods are mentioned. For decades these have been small scale, "fringe" technologies, too expensive and impractical to replace fossil fuel power. Back in our March issue we briefly mentioned a proposal to combine wind and solar power in a massive "power station". It's progressing beyond the drawing board . . .*

**By Sammy Isreb**

**Melbourne-based EnviroMission** is an energy company with a difference. That much is obvious from their plans to build a 1000 metre tall 'power station' 70km east of the Victorian town of Mildura.

By September 2005, all things going to plan, they aim to have built not only the world's tallest manmade structure along with the world's largest "greenhouse" – but a 200MW solar power station into the bargain.

Scientific testing has already commenced at the proposed site.

### The Principle

The Solar Mission project is based on the "Solar Tower" design by Professor Jorg Schlaich from the University of Stuttgart, Germany. The basic principle of operation is the use of the Sun's radiation to heat a very large body of enclosed air. Being warmer than the surrounding atmosphere, this air will begin to rise. By causing it to flow through windmill-style turbines on its journey up a tall chimney, electricity can be generated.

Obviously, generating 200MW of power in this way is no mean feat. The 'greenhouse' collector will be a roughly circular canopy of transparent plastic material measuring approximately 5km in diameter. This canopy, or roof, will slope upwards towards the centre drawing in air from the edges. In the centre will reside the tower, a 1000-metre-tall structure with a base around 170 metres wide.

On a sunny day, the air at the bottom of the tower will be around 35°C greater than the ambient air temperature, causing it to flow at roughly 15 metres per second.

In the lower atmosphere, as a general rule, temperatures fall by around 1°C per 100 metres of altitude. Thus at the top of the tower, the ambient air temperature will be around 10°C cooler than that at the bottom, without even taking into consideration the heating effect of the greenhouse.

About 40 metres up from the ground, 32 Kaplan-style turbines placed in the chimney will be driven by the rising air, in turn driving generators.

An increase in generated power could be achieved by either increasing the size of the solar collector or the height of the chimney, or both.

## Night Generation

One of the most attractive features of the Solar Tower over that of traditional solar generation methods is its capacity to generate electricity under cloud cover, or even during the night.

In order to achieve this, sealed water tubes are placed under the canopy, filled only once during manufacture. During daylight hours incident solar radiation will heat this very large mass of water. At night, that heat will be released. Varying the amount of water under the canopy will alter the output versus time of day profile of the power station.

Through this design, the Solar Tower technology avoids becoming a rapid peak generator, instead having the capacity to produce a much smoother load curve, with very low output variance. This aids in interconnection to the supply grid, avoiding the need to coordinate generation and demand peaks which normally plague green power production methods.

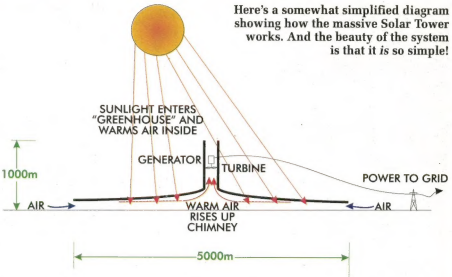
## Pilot Program

For seven years a pilot 50kW prototype Solar Tower plant was successfully operated in Manzanares, Spain. Built by the Spanish government in collaboration with designer Professor Jorg Schlaich, the plant proved the technology to be technically feasible.

Operated from 1982 until 1989, this pilot plant featured a 195-metre-tall chimney, with a collector diameter of 240 metres. Operational data acquired over this 7-year period has been used in the scaling and design of the proposed 200MW plant.

It is this successful pilot plant operation which sets apart the Solar Mission project from other large scale speculative alternative energy generation projects.

**Here's a somewhat simplified diagram showing how the massive Solar Tower works. And the beauty of the system is that it *is* so simple!**




## Site Determination

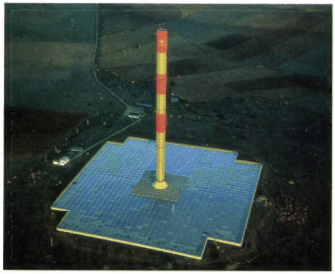
Currently the Mildura site is the favored location for the Solar Mission plant, with geotechnical testing being undertaken to confirm its suitability. With lessons learnt from the Spanish plant, final site determination will be made using the following criteria:

- Solar Radiation Levels
- Weather Patterns
- Geological Stability
- Access to the Electricity Grid
- Geographical features
- Government and community support

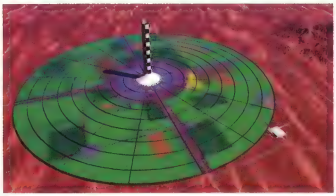
## Economic Feasibility

Calculating the production cost of Solar Tower electricity is much simpler than that of traditional coal-sourced electricity.

While coal plants have many cost inputs, including fuel, mining and transport, plant maintenance and even mining site remediation, the major cost for the Solar Mission is the capital cost of production (land acquisition and building) and associated finance costs. And some Governments have started to place taxes on major pollut-



**It's not some crazy idea which will never work: these photos show the pilot plant built some 10 years ago at Manzanares in Spain. Yes, it *does* look like a greenhouse!**



**This "viewed from above" drawing gives an even better idea of the massive size of the project, both solar collector and chimney. Compare the road and building scale to that of the collector and tower!**

ers – coal-fired power stations are firmly in their sights.

Since the operation and maintenance cost is comparatively low, a direct correlation between the prevalent interest rate and the electricity production cost can be made. With an interest rate of 11% and a 4-year cycle to production, the cost of 'solar' electricity is a mere 20% higher than coal generated power. With an interest rate of 8% (roughly that currently available), the cost of solar electricity will match that of coal-powered plants.

## Environmental Benefits

Compared to Victoria's coal-generation facilities, the 200MW Solar Mission project is relatively small. However, it will provide enough electricity for around 200,000 typical Australian homes.

Electricity demand, and thus selling price, is highest during the hottest days of the summer months, at which time the Solar Mission plant will be at its production peak. Each year it is estimated that the plant will reduce carbon dioxide output by an astounding 900,000 tonnes, satisfying both Australia's Kyoto treaty obligations and the 1997 federal legislation stipulating that 9500GWh of the nation's electricity must come from clean, green renewable sources by 2010.

With such a focus on green electricity, a successful implementation by EnviroMission could very well make them leaders in this new market.

## Conclusion

If the preliminary site testing yields positive results and all regulatory hurdles are met, a 'world first' in commercial green power generation technology could be up and running in Victoria by late 2005.

If this large-scale project proves successful it could revolutionise environmentally-friendly power generation in temperate climates.

Admittedly, Solar Tower technology will probably never fully replace the ease of tried and proved fossil fuel technologies but it will go a long way to redressing the incredibly heavily reliance on non-renewable technologies. And that's a step in the right direction.

**Acknowldegement**: Thanks to Solar Misson for the use of their illustrations. **sc**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*Do you spend long periods on the phone? Would you like to have your hands free for taking notes, using a computer or other tasks? Well now you can, by building this headset adaptor which can be used with most phones which use RJ11 modular plugs and sockets.*

# Telephone Headset Adaptor

By JOHN CLARKE

**Some people have** "prehensile" necks and can quite easily hold a phone handset between their chin and shoulder so they can talk "hands free" and take notes, etc. Other people are normal and can't do it.

But we'll give you a tip: even if you can do it, it isn't good for your neck anyway. Ask your local chiropractor how many business people they see with crook necks – and most are caused by holding a phone handset without hands.

Instead, do what they do in call centres: get yourself kitted up with a phone headset and build this little adaptor to connect it to your phone. It makes life so much easier if you have to spend long periods on the phone.

What the headset adaptor does is connect between your telephone and the handset. To use the phone, the handset is lifted off the rest ("off-hook") to answer or make a call. A switch on the adaptor then allows you to select the handset or the headset. To hang up, the handset is placed back on the phone as normal.

The adaptor is housed in a small plastic case with two RJ11 4P/4C modular sockets at each end. These US-style modular sockets are used on just about all phones these days, so the handset can just be plugged into the adaptor's output socket.

The input socket on the adaptor connects to the telephone using another curly handset lead. The headset is then plugged into a 3.5mm stereo socket on the adaptor.

Essentially the adaptor works by connecting either the normal handset or the headset to the telephone. The handset has a small loudspeaker in the earpiece and a microphone and these are connected to the telephone via four leads and the RJ11 socket.

The headset also has a small loudspeaker for the earpiece and a microphone on a flexible support which you can bend to suit yourself. The headset has a figure-8 shielded cable running to a 3.5mm stereo jack. One wire carries the microphone signal while the second wire carries the loudspeaker drive. The shield wires are commoned to the sleeve connection on the jack.

Therein lies a problem. While the ground (shield) wires for the headset microphone and earpiece speaker are commoned, a phone handset has completely separate wiring to the microphone and loudspeaker. Unfortunately, the two ground wires on the handset cannot be simply shorted together to form a common connection suitable for directly connecting to the headset.

This is because most telephones drive the loudspeaker with a push-pull output, with both lines swinging above and below the microphone ground level. Thus shorting one loudspeaker output to ground will short out one side of the loudspeaker amplifier in the telephone.

Another problem with connecting the headset to the telephone is that its loudspeaker impedance is a nominal 32Ω while typical telephone handsets have a nominal 128Ω impedance. Connecting a 32Ω loudspeaker could cause the amplifier within the telephone to be damaged and at the very least, the mismatch will result in greatly reduced sound level.

Fortunately, both of the above problems can be solved by using a transformer. The transformer isolates the drive to the headset loudspeaker so that it can be connected to the microphone common lead without shorting the telephone amplifier. And the transformer can be wound to provide the impedance transformation from 128Ω down to 32Ω. So as far as the telephone is concerned, it sees a 128Ω load when the transformer is driving a 32Ω loudspeaker.

One further difference between the handset and headset is that some handsets use a dynamic microphone while others use an electret type. The headset uses an electret microphone which requires a DC supply and so the headset adaptor includes a 1.5V cell. This will not be required for use with telephone handsets which have an electret microphone; they can directly power the headset microphone.

Confused? Have a look at the circuit and all will be made clear.

## Circuit diagram

Fig.1 shows the circuit of the telephone headset adaptor. It shows the four lines that connect from the RJ11 socket on the phone to the socket

**The complete adaptor, shown here with its microphone and earphone headset. The white curly cord goes off to the telephone "handset" socket while the handset itself plugs into the socket at the bottom of the unit.**

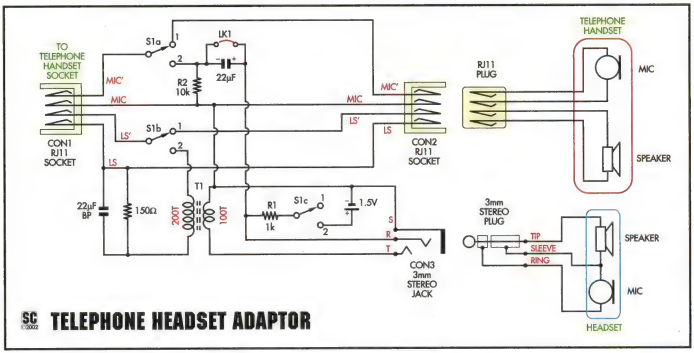



**Fig.1: the circuit of adaptor: it is used in conjunction with the existing handset to give hands-free operation. Not all phones are suitable – the text explains how to check if yours can be used.**

(CON1) in the adaptor and these have been labelled MIC, MIC', LS and LS'. These refer to the microphone and loudspeaker lines. The MIC line is the common ground for the microphone and the loudspeaker in the headset.

Switch S1 selects between the headset and handset. When it is in position 1, it connects the handset (CON2). When S1 is in position 2, the headset (CON3) is selected. The MIC line is normally connected to the headset microphone ground, while the MIC' connects to the microphone positive side via link LK1 or the 22µF capacitor. The capacitor removes the DC voltage from the microphone if it is supplied with current via the 1kΩ resistor and the 1.5V cell. The 10kΩ resistor holds the MIC' DC voltage at ground.

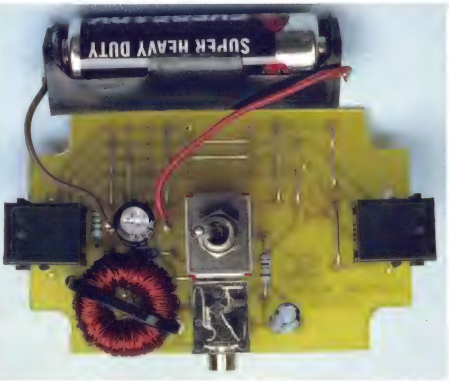
As we mentioned before, this electret supply is only required if the telephone itself does not provide power (ie, when the handset microphone is a dynamic type).

If the handset uses an electret, then the headset will be powered directly and the 10kΩ and 1kΩ resistors, the 1.5V cell and the 22µF capacitor can be omitted. In this case connection of the positive side of the microphone to the telephone is made using link LK1.

The headset loudspeaker is driven via transformer T1. The LS and LS' lines from the telephone drive the primary side of T1 via a 22µF bipolar capacitor and 150Ω resistor. At frequencies above about 180Hz, the 22µF capacitor can be considered close to a short circuit and the transformer then directly drives the loudspeaker connected to the secondary.

The transformer is wound with 200 turns on the primary and 100 turns on the secondary. This provides a 4:1 impedance transformation so that the LS drive from the telephone "sees" 128Ω while driving the 32Ω loudspeaker.

The 22µF capacitor is included to protect the telephone's audio amplifier from driving a very low impedance at low frequencies. This would




**This version of the adaptor is for electret mics which require power (hence the 1.5V battery). If your phone already has an electret, this should not be needed.**

happen since the primary winding of T1 is about 1.7Ω at DC, only rising to above 128Ω at beyond 180Hz.

Thus the 22µF capacitor introduces impedance at these lower frequencies. The 150Ω resistor allows DC current to flow if this is required for correct operation of the telephone amplifier.

## Telephone testing

Not all phones are suitable for this adaptor circuit. This is because there is no amplification to compensate for any differences in sensitivity between the loudspeaker or microphone. So if you have trouble hearing using the handset of your telephone you probably will have more difficulty hearing with the headset.

There is a small reduction in volume level when changing to the headset because of losses in the transformer and possible lower sensitivity of the loudspeaker. Microphone sensitivity is less of a problem between headset and handset but this may also vary with different telephones.

Before you can fully assemble the Telephone Headset Adaptor, some tests will need to be made to the telephone, to find out which connections are for the microphone and which are for the loudspeaker.

This is done by partially assembling the adaptor PC board and then using a multimeter to measure some voltages and resistances. These measurements need to be made since it seems that each telephone is different; there is no standard for the pinouts for the handset RJ11 socket.

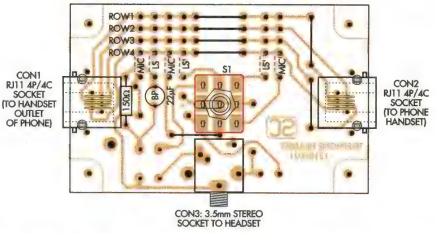



**Fig.2: initial assembly of the PC board, ready for connection to the 'phone and checking which links need to be inserted in which holes.**

## Construction

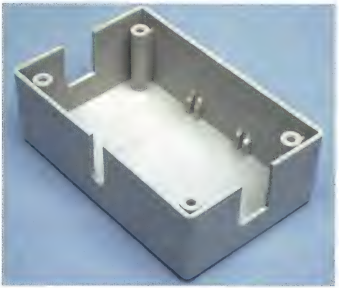
The Telephone Headset Adaptor is constructed on a small PC board coded 12107021 and measuring 79 x 49mm. All the components including the sockets and switch mount directly onto this PC board. It is housed in a small utility case measuring 82 x 54 x 31mm.

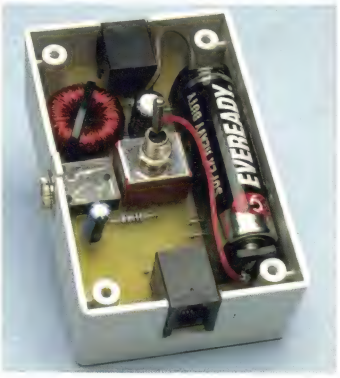
Begin construction by checking the PC board for possible shorts and breaks in the copper tracks.

The four corners of the PC board need to be cut to shape to clear the integral pillars in the case. You can do this by drilling out the centre hole with a 6mm drill, breaking off the unwanted corner portion and then filing to the contour shown on the copper side of the PC board.

You may also need to drill holes for the integral mounting pins on the RJ11 sockets so that they clip in correctly to the PC board. The Altronics socket differs slightly to the one sold by Jaycar and so we have provided both hole positions for the mounting pins. Also check that there are suitable (1.5mm) sized holes required for the pins on the switch and 3.5mm stereo socket.

The toroidal transformer is secured with cable ties through the holes as






**Here's how we cut the slots in the box and filed out the guides to acccommodate the PC board, with that accommodated board shown at right! It's a tight fit so you have to be careful when cutting the slots. Don't throw the waste out from the end slots: with careful cutting and filing you can make a tiny piece to take up the slot in the side (above the 3.5mm socket).**

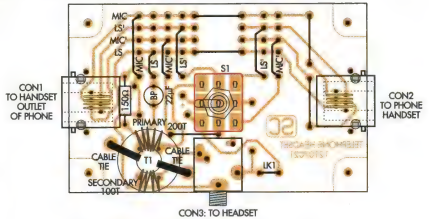



**Fig.3: fully completed PC board for a phone with an electret microphone. These links suit a Telstra Touchfone 400.**

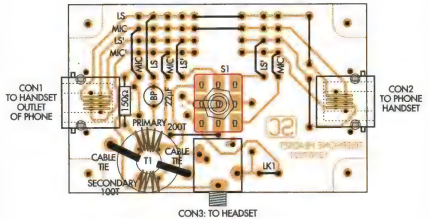



**Fig.4: similar to above, but this one suits a Sharp F0165 fax machine. Each phone must be individually checked and the links installed as appropriate.**

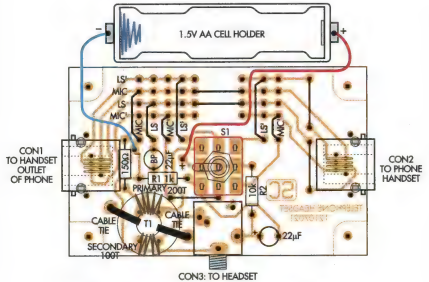



**Fig.5: the typical wiring for a phone which uses a dynamic microphone, requiring bias voltage for the electret mic used in the headset. This happens to suit an NEC telephone attached to a PABX system.**

shown in Fig.3. Check that these holes are of the correct size.

The plastic case has integral side clips which will need to be removed so that the PC board will slide into the case. Remove these with a sharp chisel or utility knife (ie, Stanley) and check that the PC board fits into the case without fouling.

The initial assembly of the PC board is shown in Fig.2. Install all the links as shown. The RJ11 sockets can be installed now along with the 3.5mm stereo socket. The switch may need its pins crimped together slightly with pliers to allow its eyelet terminals to be inserted into the holes. You can also install the 150Ω resistor and 22µF bipolar capacitor now.

## Testing the telephone

At this stage, the telephone connections will require testing (before the final components are fitted) to determine the linking required.

The curly lead from your telephone handset back to the phone itself usually has an RJ11 connector plugging into a socket on the phone (usually on the back or side but often underneath). This must be unplugged. You do this by squeezing the release tab attached to the RJ11 connector towards its lead and gently pulling on the lead.

Plug the now-free RJ11 connector into the handset socket (CON2) on the adaptor. Then use another RJ11 to RJ11 phone cord to make the connection between the phone socket (CON1) on the adaptor and the now-vacated socket on the phone.

Now check that your phone still works. You should hear dial tone in the earpiece and you should hear your voice in the earpiece loudspeaker when speaking loudly into its microphone. If it does not work, check the connecting cords or indeed your soldering).

In this test, the handset is connected straight through the adaptor so it should work normally.

Now set your digital multimeter to read AC millivolts, lift the handset and check which two links on rows 1 to 4 have AC voltage on them. We measured up to 46mVAC with a Telstra Touchfone 400 connected and 23mV with a Sharp FO165 facsimile telephone. This is the dial tone signal across the earpiece loudspeaker.

Disconnect the lead between the adaptor and the telephone and set your

multimeter to read "ohms". Now connect the multimeter to the two links that showed the ACmV reading. There should be a scratching noise heard in the earpiece of the handset when the multimeter probes are connected and disconnected to these links.

If this is so, these two links are the loudspeaker connections. Check the DC resistance across the loudspeaker, which will probably be between 100Ω to 150Ω. If it is lower than this, make a note of its value for later.

Label one of the rows connecting to these links as LS and the other row as LS'.

The other two rows are the microphone connections. Set your multimeter to read DC Volts and connect the lead back into the telephone. Lift the handset and measure the voltage across the microphone links. If there is a DC voltage of around 1V to 6V, then the microphone is almost certainly an electret. Label the row with the positive voltage as MIC' and the other row as MIC.

If there is no DC voltage or very little voltage then the microphone is a dynamic type. Disconnect the lead to the telephone and measure the resistance across the microphone links. The resistance will probably be around 100Ω to 1000Ω. This indicates the microphone impedance.

Check if there is any resistance between one of the microphone links and one of the loudspeaker links. If there is a low resistance between two of them, label ***this*** row of microphone links as MIC. Label the other row of microphone links as MIC'.

If there is a high resistance, then simply label one link as MIC and the other as MIC'. These may need to be changed later if the microphone in the headset does not work.

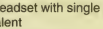
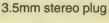
Once you know the connections, the links can be installed. The four PC connections to the left of S1 labelled MIC, LS, MIC' and LS' connect to the rows labelled the same. So MIC connects to the row marked MIC, LS connects to the row marked LS and so on.

The links above S1 will need altering so that only the MIC and LS links are connected. Link connections to the right of S1 connect LS' to the row marked LS' and MIC' to the row marked MIC'.

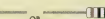
We show three examples of how we assembled the PC board for three different telephones and these are shown in Figs.3, 4 & 5. We labelled each row with the MIC and LS designations after the measurements were made and the links were placed as shown. Note that Fig.3 and Fig.4 show connections for telephones that had electret microphones in the handset while Fig.5 shows a telephone which had a dynamic microphone. The 1.5V cell provides the power for the headset electret when S1 is switched for headset use.

Note that R2 is set at 10kΩ. This may need reducing in value if the signal from the electret headset microphone is found to be too high. This may become apparent during subsequent testing if your voice is too loud to the person being called. (You can

## Parts List – Telephone Headset Adaptor

1 PC board coded 12107021, 79 x 49mm
1 plastic utility case, 82 x 54 x 31mm
1 front panel label, 79 x 50mm
1 monophonic hands-free headset with single 3.5mm stereo plug lead; Jaycar AA-2018 or equivalent
1 3-pole double-throw toggle switch (S1)
2 4P/4C RJ11 PC-mounting modular sockets; Jaycar PS-1470 or equivalent
1 3.5mm stereo switched PC-mounting socket
1 18 x 10 x 6mm ferrite toroidal core (Jaycar LO-1230 or equivalent) (T1)
1 3m 4P/4C telephone handset curly cord
1 22µF 50VW bipolar electrolytic capacitor
1 150Ω 0.25W 1% resistor  OR 
1 500mm length of 0.8mm tinned copper wire
1 8m length of 0.25mm enamelled copper wire
1 50mm cable tie

**Extra parts for powering electret microphone**

1 AA cell holder
1 AA cell (1.5V)
1 22µF 16VW PC electrolytic capacitor
1 10kΩ 0.25W 1% resistor OR 
1 1kΩ 0.25W 1% resistor 
2 PC stakes
1 100mm length of red hookup wire
1 50mm length of black hookup wire

**A close-up of the completed adaptor with front panel fitted. While the plastic screw-hole covers mar the appearance of the panel a little, you will need to gain access to the inside if you have a 1.5V battery. If you don't need the battery, the panel could be glued over the screw holes and the covers left out – once everything is checked and working, of course!**

reduce R2 down to the a value as small as the DC resistance measured for the dynamic handset microphone).

## Winding the transformer

The transformer is wound using 0.25mm enamelled copper wire on the toroidal core, with 200 turns for the primary and 100 turns for the secondary.

The frequency response of the resulting transformer is quite good, in fact more than adequate for telephone work. Our prototype was reasonably flat from around 100Hz to above 20kHz.

Wind the primary and secondary turns evenly distributed over the entire core (it doesn't matter which order and they don't have to be neat, side-by-side turns) and terminate into the holes provided on the PC board. The polarity of the windings also does not matter.

The wire ends will require the insulation to be stripped off them before soldering. Some coatings can be removed with a hot soldering iron. Alternatively, use some fine grit sand paper to remove the coating. The transformer assembly is then secured with a cable tie.

Place the PC board assembly in position over the case and mark out the cutout positions for the sockets. We cut the box with a fine-toothed hacksaw and broke out the pieces with pliers. The cutouts were then filed to shape. Only cut the holes to the depth of the sockets plus 2mm.

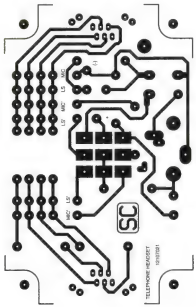
Also, a slot is required in the side of the case for the 3.5mm socket. Test the PC board for fit into the case and adjust any of the cutout sides accordingly.

We made up a rectangular piece of plastic salvaged from the socket cutouts to fill the slot above the 3.5mm socket once it is inserted in the box.

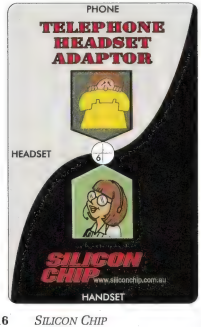
The lid will require a hole for the toggle switch. You can use the front panel label as a guide to its positioning. Glue the front panel label to the case and cut out the holes with a sharp knife.

Finally, you can test the headset adaptor on the telephone. Check that the volume is satisfactory and that the listener on the other telephone can hear. Switch between handset and headset to check that the levels are similar.

If your telephone uses a dynamic microphone, the MIC and MIC' links may need to be swapped so that the electret in the headset will work.




**Full-size artwork for the PC board (above) and the front panel (below). These can also be downloaded from www.siliconchip.com.au**



**This is the Jaycar headset (AA2018) on which the project is based. Other headsets may be suitable but make sure the wiring to the 3.5mm stereo plug is the same.**

## Variations

If the telephone and headset use a dynamic microphone, you do not need R1, R2, the 22µF polarised electrolytic capacitor and the 1.5V cell. Install link LK1.

If the telephone uses an electret microphone in the handset and the headset is dynamic, you do not need R1, R2 and the 1.5V cell. However, the 22µF polarised capacitor will be required and it will need to be inserted with the opposite polarity to that shown on the PC board component overlay. SC

## Catering for different headset speaker impedances

As presented, the toroidal speaker matching transformer for this project has 200 turns for the primary and 100 turns for the secondary. This provides a nominal 4:1 impedance transformation from the nominal 128Ω speaker in a typical telephone handset, down to the 32Ω speaker found in typical headsets.

However, if the loudspeakers in your handset and headset have greatly different impedances to this, you can tailor the turns ratio to suit.

To calculate the turns ratio required, divide the handset loudspeaker impedance by the headset loudspeaker impedance and take the square root of this value.

For example, if the telephone handset loudspeaker impedance is 150Ω and the headset loudspeaker microphone is 16Ω, the turns ratio required will be the square root of 150/16 or about 3:1. For this ratio, we would suggest 240 turns for the primary and 80 turns for the secondary.

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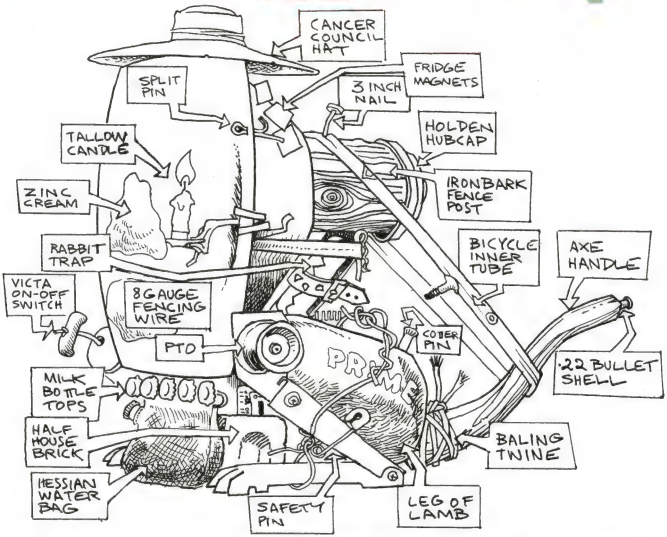


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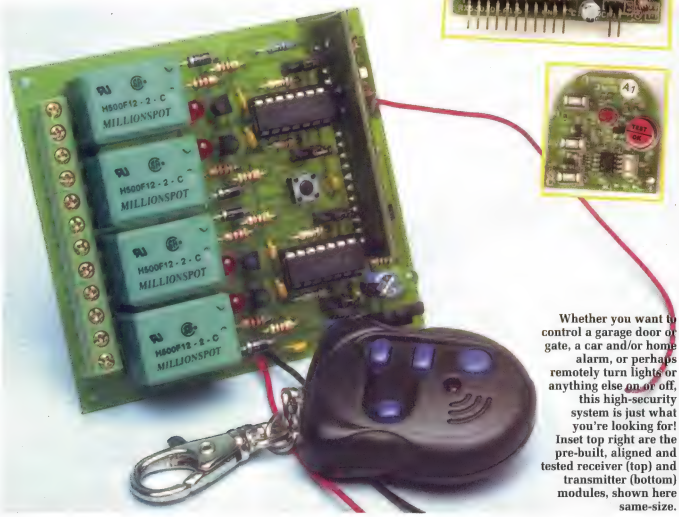
# A Rolling Code 4-channel UHF Remote Control

**This is one very clever remote control. With rolling code, it's close-to-impossible to electronically "crack". With four channels, all either latching or momentary operation, it's extremely versatile. With a sensitive prebuilt receiver, it's long range. With up-to-16 keyring-size transmitters, it's go-anywhere. And the kit even includes the keyring!**

By Ross Tester




Whether you want to control a garage door or gate, a car and/or home alarm, or perhaps remotely turn lights or anything else on or off, this high-security system is just what you're looking for! Inset top right are the pre-built, aligned and tested receiver (top) and transmitter (bottom) modules, shown here same-size.

**We've presented a number** of remote (radio) control devices in the past. None has been more secure than this one. To guess the code combination, you're going to need something like 23 billion years. But don't bother: the next time it's used, the code will have changed anyway.

That's the advantage of a rolling code (or "code hopping") system. We explain what this means, and does, later in this article.

Suffice to say at this stage that it makes one v-e-r-y secure system. For all intents and purposes, it is impossible to electronically "crack". Go on, give it a go – we'll see you in a few million years or so!

## The transmitter

It's probably not necessary to say it but there are two parts to this project, a transmitter and a receiver.

First of all, there is the tiny 4-channel "key-ring" transmitter which, fortunately, comes 99% pre-assembled.

We say fortunately because it's just about all SMD (surface mount devices) which, while not impossible for the hobbyist to work with, requires some rather special handling. You are spared that!

All you have to do with the transmitter PC board is solder on the two battery connectors and place it in the case (with battery).

The battery contacts are slightly different: the one with a spring is for the negative battery connection – it goes on the righthand side of the PC board with the only straight side of the PC board at the bottom.

You may find, as we did, that some of the holes for the battery connectors are filled with solder. This is easily melted during installation.

Once this is done, it's just a matter of assembling the board in its keyring case. Incidentally, the keyring case and battery are all supplied in the kit.

The transmitter itself is in the licence-free 433MHz LIPD band (it's actually on 433.9MHz). As with most devices of this type these days, it is based on a SAW resonator (that stands for surface acoustic wave, so now you know!). This keeps the circuit very simple but enables excellent performance.

Without wanting to get into the nitty-gritty of SAW resonator operation, in essence it controls the RF side of things while a dedicated chip controls the complex digital coding.

The receiver (which we'll get to shortly) can handle up to 16 transmitters so if you have a really big family or maybe have a secure company carpark you want to give a certain number of people access to, you can do so simply by purchasing more transmitters.

The transmitter has four pushbutons, one for each of the four channels.

Of course you don't have to use all four channels – just one will control most garage door openers, for example – but it's nice to know there are four channels available.

And before we move off the transmitter, up to three channels can be pressed simultaneously and the receiver will react to all three (it won't handle four at once, though).

Finally, as well as multiple transmitters, you can use more than one receiver if you wish.

Each receiver "learns" its transmitter(s) so you can have a multiple system controlling, for example, the garage door, the car doors, the car alarm, the home security system – in fact, anything your little heart desires.

## The receiver/decoder

Now we move on to the heart of the system, at least the bits you have to put together to make it work.

In fact, there are two parts to the receiver as well. There is a 433MHz receiver module which comes assembled, aligned and ready to go. This solders into an appropriate set of holes on the main PC board once you've finished assembling that board.

The main PC board contains the electronics which process the output from the receiver.

The receiver checks the incoming code and if valid, sends a signal to one of four outputs depending on which button was pressed on the transmitter).

From here, depending on how the four jumpers are set on the board, the signal goes either direct to an NPN transistor relay driver (for momentary operation – the relay is energised while the button remains pressed) or to a D-type flipflop and then to the transistor relay driver (for alternate operation – press once and the relay latches, press again and the relay releases).

The flipflops change state (toggle) each time a postive going pulse appears at the clock input. This is achieved by the connection from the Q-bar output to the D input via an RC network.

The circuit has a power-up reset. When power is first applied, the Q outputs of the flipflops are reset low by the 0.1µF capacitor and 1MΩ resistor on the reset (S) inputs.

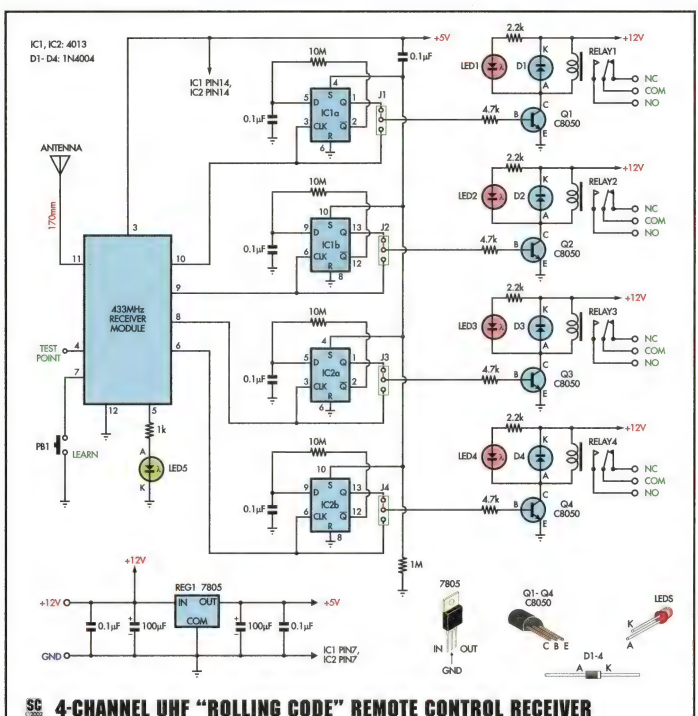
Reset is caused by sending the reset inputs of all flipflops high. Once the capacitor is charged, the voltage at the reset inputs of the flipflops falls to virtually zero, allowing normal operation

It is perfectly acceptable to have a mixture of momentary and latched modes amongst the four channels. It's up to you.

But if you only require momentary action (for example, as needed by

## SPECIFICATIONS

- UHF (433MHz) licence-free (LIPD band) operation
- Long range – prototype tested to 100m+
- Pre-built and aligned transmitter & receiver modules
- Rolling-code ("code hopping") operation (7.3 x $10^{19}$ codes)
- Receiver "learns" transmitter coding
- Receiver can handle up to 16 remotes
- Transmitter can handle any number of receivers
- 4 channels available, each either momentary (push on, release off) or latching (push on, push off) via jumpers
- Code acknowledge LED and channel status LEDs
- Each channel relay contacts rated at 28VDC/12A (single pole, changeover)
- 12V DC operation (6mA quiescent; 150mA all relays actuated)




## 4-CHANNEL UHF "ROLLING CODE" REMOTE CONTROL RECEIVER

**Fig.1: the circuit of the "control" section of the receiver unit. We haven't attempted to show the 433MHz receiver itself, nor the transmitter, as these are both pre-assembled modules, saving you a lot of difficult work!**

some door openers/closers) the flip-flops, along with their associated RC network components and the four header pin jumper sets, could be left out of circuit. (You'd then need four links on the PC board to directly connect the receiver outputs to their respective transistors.)

Along with spike suppression diodes across each relay coil, part of each relay driver circuit also includes an acknowledge LED to give a visible output of what's happening.

There is also a "valid signal acknowledge" LED attached to the 433MHz module, which lights when valid code is being received.

Each of the four identical relays has contacts rated at 28VDC & 12A, so can be used to control significant loads. The wide track widths on the PC board also allow high currents.

The relay contacts could, of course, also be used to switch higher-rated relays or you could replace the acknowledge LED with an opto-coupler.

The relays themselves are single pole but have normally open (NO) and normally closed (NC) contacts. These states refer to the unenergised state of the relay (ie, the NC contacts go open when power is applied to the relay coil and vice-versa).

## ASSEMBLING THE REMOTE CONTROL:

**The photo above shows seven of the eight parts you should find when you take the bits out for the remote control (the battery is missing!).**
**Above centre shows the two battery connectors soldered in place on the top of the PC board, above right shows the same thing from the other side. Don't mix up the connector with spring and the connector without. Finally, the photo at right shows the PC board in place, with battery, in one half of the keyring case. The blue pushbuttons are all on one plate – they fit in as shown but can easily fall out. As you push the two halves of the case together, make sure the pushbutton plate stays in place. The keyring itself also fits into the notch in the case as you push the two halves together.**

The only other components on the board are a simple 5V regulated supply, consisting of a 7805 3-terminal regulator and a couple of capacitors. This supply powers the 433MHz module and the 4013 flipflops. The relay coils are powered direct from the 12V supply.

### Construction

Start by soldering in the two battery terminals to the transmitter PC board, in the positions shown in the photographs.

Place the completed board in the keyring case, making sure the pushbuttons stay in position.

Push the two halves together with the battery in place (and the right way around – see pictures), with the keyring clip sandwiched between the two halves.

One screw holds the two halves of the transmitter case together.

Press each of the four buttons and ensure that the LED lights each time. If it does, you can be reasonably sure that the transmitter is working properly. Put it to one side while we move on to the receiver.

### Receiver board

As usual, check the receiver PC board for any defects before assembly. Then solder in the resistors, capacitors, diodes, IC sockets (if used) and the four header pin sets (which select momentary or latching function).

If you use IC sockets, make sure they go in the right way around – the notch is closest to the edge of the PC board.

The "learn" pushbutton switch solders in place between the IC sockets. These have two pairs of pins which are not identically spaced – the switch should be an easy fit in the PC board if you get it the right way around. If in doubt, check the "closed" state with your multimeter.

Now solder in the semiconductors – the regulator, diodes, transistors and the LEDs as shown on the component overlay. Watch the LED and transistor polarities – each is opposite to its neighbour!

The last things to be soldered in place before the 433MHz receiver module are the four relays and the six output terminal blocks. The relays will only go in one way but the terminal blocks could be mounted back-to-front, making it almost impossible to get wires into them! (The "open" side of the terminals go towards the edge of the board, in case you were wondering!)

At this point, check your assembly for any solder bridges, dry joints or missed joints.

You might also now solder in the three wires – two connect 12V power while the third is the antenna. Make the power leads the necessary length to reach your supply.

When the antenna wire is soldered in, measure exactly 170mm from the PC board and cut the wire to this

length. This makes it resonant at 433MHz.

You should not have any bare wire(s) emerging from the end of the antenna – this could short onto something nasty and do you/it/something else some damage! If necessary, wrap a little insulation tape around the end of the antenna wire – just in case!

Plug the two ICs into their sockets, again watching the polarity. The notches should line up with the notches in the sockets (assuming you got the sockets right!)

OK, we're almost there. Place the receiver module in its appropriate holes along the edge of the PC board. It will only go one way (incidentally, take care not to move the coil or touch the trimmer capacitor).

Solder each of the module pins into position (there are 13 of them – don't forget the two by themselves) and your receiver is finished.

## Power supply

The receiver unit is designed for 12V battery operation and power requirements are pretty modest. At rest, (ie, no relays operating), it draws only 6mA and even with all relays actuated, the current is just a smidgeon under 150mA.

Therefore, most alarm-type batteries (eg, SLAs) will be more than adequate.

We had it operating for a couple of weeks on a 7Ah 12V gell cell, periodically pressing the remote control just for the hell of it, without recharging the battery. In fact, at the end of this time the battery voltage changed only a few tens of millivolts – probably not much more than you would expect during shelf life.

Therefore, just about any 12V battery would be acceptable, even a couple of 6V lantern batteries in series or even 10 C or D-size Nicads.

Of course, you could also use just about any garden-variety 12V or 13.8V DC (nominal) plug-pack supply.

The relays won't worry about a few extra volts and the circuit has the on-board 5V regulator to ensure the electronics get the right voltage. Any DC plugpack over about 200mA capacity should be fine.

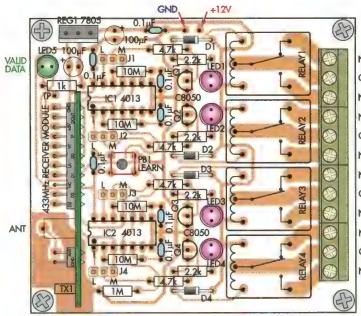
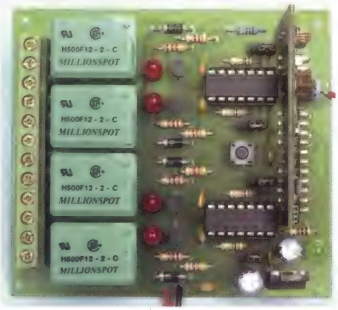



**Fig.2 (above): the component overlay of the receiver module with the full-size photograph at right. Just to confuse you, we've shown the board turned 180° compared to the diagram above!**




## Learning and testing

Looking at the board with the outputs/relays on the left side, move all header pins to the right side (latching).

Apply power and you should see absolutely nothing happen. So far, so good.

Now press the "learn" button once, then within 15 seconds press button one on the keyring transmitter for a second or so. Button one is the one all by itself on one side of the transmitter. The receiver then learns the encryption from the keyring transmitter – and remembers it.

Now all four buttons on your transmitter should alternately close and open the appropriate relay and light/switch off its associated LED.

Change the four jumpers over to the opposite way and all four buttons should now pull in a relay and light a LED while ever they are pressed – and release it/dim it when let go.

And that's just about it. Now all you have to do is select the jumpers the way you want them and connect the external devices you wish to control. Note that each relay has a normally open and normally closed connection as well as common, so you have a lot of flexibility at your disposal.

## Want even more security?

We mentioned before the one major drawback with any remotely controlled security application, whether that

# What is "Code Hopping" or "Rolling Code"

These two names usually refer to the same thing – in a nutshell, a security system for a security system.

It's a way of preventing unauthorised access to a digital code which might be transmitted via a short-range radio link to do something: open a garage door, lock or unlock a car and perhaps turn its own security system on and off – and much more.

But before we look at these terms, though, let's go back in time to the days before code hopping and rolling code.

Short-range radio-operated control devices have been around for a couple of decades or so (at least, in any volume). The earliest ones that I remember simply used a burst of RF, at a particular frequency, with an appropriate receiver.

It's not hard to see the shortcomings of such devices. Simply sweeping the likely band(s) with an RF generator attached to an antenna would more often than not achieve the desired result (desired for the intruder, that is).

It didn't take long for crooks to latch on to this one (do you like that metaphor?). So manufacturers decided to make it a bit harder for them by modulating the RF at a frequency (or indeed multiple frequencies in some cases) "known" to the receiver.

Some used the standard DTMF tones generated by phone keypads because they were very cheap and made in the millions.

"Oh, gee," said the crooks. Now we'll have to use an RF oscillator with a modulator. Or maybe even a DTMF keypad!"

Duh! (Still, it probably seemed like a good idea at the time. . .)

Ever one step ahead, the manufacturers went with this (then) new-fangled digital stuff and made each transmitter send a particular code which was matched to the receiver. This was usually done by way of DIP switches in both transmitter and receiver.

With eight DIP switches (probably the most common because 8-way DIP switches were common!), you would have $2^8$ or 256 codes available. So you and your next-door neighbour could have the same type of garage door opener on the same frequency and the odds would be pretty good that their door would stay down when you pressed your button.

The problem with this, though, is that the transmitter spurted out exactly the same code every time (unless, of course, both sets of dip switches were changed). Enter the crooks again.

With a suitable receiver, called a "code grabber", if they got within a few tens of metres of you they could scan for the RF signal and record your code without you knowing anything about it (for example, as you left your car in a carpark and pressed the button on your remote to lock the doors and turn on the alarm).

Once you'd gone, they simply "played it back" using the same code grabber. Presto, one missing car. Or one house burgled, etc etc.

Even without a code grabber, a smart intruder with the right equipment using digital techniques and trying eight combinations per second, could crack the code in no more than 32 seconds – and probably much quicker.

It's hard to believe the gall of some organisations openly flogging such devices, euphemistically disguising them (justifying them?) with names such as vehicle lockout recovery systems or disabled vehicle recovery systems. Then again, lock picks are sold for professional locksmiths, aren't they?

Now we move on a little. Microchip, the same people who brought you those ubiquitous PICs, invented a system called KEELOQ – better known to you and me as a rolling code.

What this does is simply present a different code every time the transmitter button is pressed. Of course, that's the easy part. The really clever part is that the receiver "learns" the algorithm which controls the code so it knows what code to expect. Once learnt, the receiver is effectively "locked" to that transmitter.

Actually, it's even cleverer than that, because the transmitted code is, for all intents and purposes, random (as far as any external device is concerned). But the receiver can still work out what the code is going to be in advance. If it gets the right code, it actuates. If not – you're out in the cold, baby!

The chances of the same code being transmitted twice in a person's lifetime is possible – but remote (at four transmissions per day, every day, it's reckoned to be about 44 years!)

Heart of this system is a Microchip proprietary IC, the HC301. It combines a 32-bit hopping code generated by a nonlinear encryption algorithm with a 28-bit serial number and six information bits to create a 66-bit code word. The code word length eliminates the threat of code scanning and the code-hopping mechanism makes each transmission unique, rendering code capture and resend techniques useless.

Even if it didn't code-hop, 66 bits allows $7.3 \times 10^{19}$ combinations, which according to Microchip would only take 230,000,000,000 years to scan!

The chip itself is also protected against intrusion. Several important data are stored in an EEPROM array which is not accessible via any external connection. These include the crypt key, a unique and secret 64-bit number used to encrypt and decrypt data, the serial number and the configuration data.

The EEPROM data is programmable but read-protected. It can be verified only after an automatic erase and programming operation, protecting against attempts to gain access to keys or to manipulate synchronisation values.

If the code is changed every time a button is pressed on the transmitter, what happens if, say a child starts playing with the remote control and continually presses buttons away from the receiver? OK, here's where it gets really clever (and you thought it was clever enough already, didn't you?).

If the button is pressed say 10 times while out of range of the receiver, no problem. But if it is pressed more than 16 times, synchronisation between the two is lost. However, it only takes two presses of a button in range to restore sync. No, we don't know how either. That's Microchip's secret!

And speaking of button presses, there are a couple of other clever things they've done. At most, a complete code will take 100ms to send (it could be as low as 25ms). But if you manage to hit the button and release it before 100ms (difficult, but possible), it will keep sending that complete code. If you hold down the button, it will keep sending that same code. And if you press another button while the first is held down, it will abort the first and send the second.

As you can see, KEELOQ is a very robust system. Sure, it's not absolutely foolproof – nothing is (eg, there's not much protection if they simply steal your transmitter!). But for most users, it gives almost total peace-of-mind. That's why the system has been adopted by so many vehicle entry/exit and alarm system manufacturers, access controllers and so on.

And that's the system that's used in the remote control unit presented here.

be for a car, a building or anything else: what happens if someone pinches your remote control?

It is possible to protect yourself against the casual button pusher on a stolen control – at least to some degree.

Having four channels at your disposal, in this remote control system, gives you the possibility of increasing security rather significantly, simply by using a combination of keys on your remote.

It is "normal" to use one button to achieve a certain function. But what if you used two buttons? It's possible because when you press the second button, even while holding down the first, the second button's code is sent.

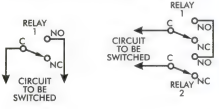



**Fig.3a (left): conventional device control with one relay. Adding a second relay in series (fig 3b, right) increases security against the casual button pusher. Both buttons must be pressed at the same time for the device to actuate.**

So if you made one button a "momentary" and linked another button's relay contacts through the first button's relay contacts, you have the situation where pressing single buttons (as most people would do) wouldn't achieve a thing.

Only you know which two buttons (or even three buttons) have to be pressed to achieve a certain function.

Fig.3 shows what we mean – the exact combination of buttons is entirely up to you! **SC**

## Parts List – 4-Channel Code-Hopping Remote Control

1 TX-4312RSA 4-channel keyring rolling code transmitter assembly
1 RX3302D A1.5 433MHz rolling code receiver module
1 PC board, coded K180, 86 x 78mm
4 miniature relays, SPDT, PCB mounting, 12V coils (Millionspot H5000xx)
1 ultramini pushbutton switch, PC mounting, N-O contacts
6 interlocking 2-way terminal blocks, PC mounting
2 14-pin DIL IC sockets (optional)
4 3-way header pin sets, PC mounting
Red & black insulated hookup wire for power connection
1 200mm length insulated hookup wire for antenna (see text)

**Semiconductors**

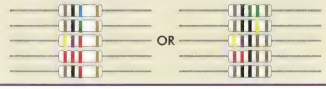
2 4013 dual "D" flipflops (IC1, IC2)
4 NPN general purpose transistors (C8050 or similar) (Q1-Q4)
1 7805 3-terminal regulator (REG1)
4 1A power diodes, 1N4004 or similar (D1-D4)
4 red LEDS, 5mm (LED1-LED4)
1 green LED, 5mm (LED 5)

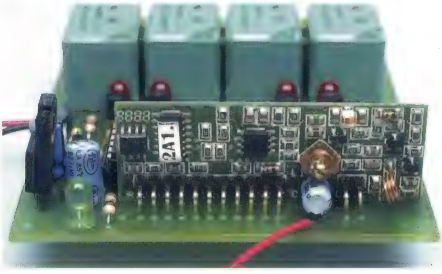
**Capacitors**

2 100µF, 16VW PC mounting electrolytics
7 0.1µF polyester or ceramic (monolithic 5mm)

**Resistors**

4 10MΩ
1 1MΩ
4 4.7kΩ
4 2.2kΩ
1 1kΩ




**A close-up look at the receiver module soldered into the main PC board. Do this last, as explained in the text.**

## Wheredyageddit?

This project and the PC board are copyright © 2002 Oatley Electronics.

Oatley have made separate kits available for both the transmitter and receiver, due to the fact that you might want more than one of each (as explained in the text).

**Rolling Code Transmitter Kit:** Complete with pre-assembled transmitter module PC board, battery contacts, battery, clamshell case and keyring clip: (TX4) $25.00.

**Rolling Code Receiver Kit:** Has the 433MHz receiver module, PC board and all on-board components as described in this article: (K180) $54.00.

Oatley Electronics can be contacted by: Phone (02) 9584 3563; Fax (02) 9584 3561; Mail (PO Box 89. Oatley NSW 2223); Email (sales @oatleyelectronics.com); Or via their website: www.oatleyelectronics.com

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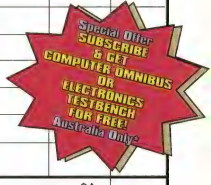


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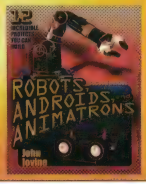

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Mar '00

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D 2844

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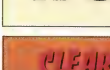

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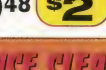

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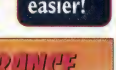

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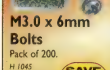

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# Applications for fuel cells

***It's all very well saying we can produce clean electrical power with only heat and water vapour as emissions but can we apply the technology economically? More importantly, will the environmental costs of producing fuel cells and their fuel actually be higher than the environmental gains made by using the technology?***

**If hydrogen becomes the fuel** of choice, what are the costs of manufacturing it and installing a completely new fuel distribution system?

Experience has shown that we should ask these questions early in the development of any new technology, no matter how great it looks at first glance. Looking at comparisons with existing fuel systems, the hydrogen fuel cell certainly comes out ahead environmentally.

Fig.1 shows clearly that hydrogen fuel cell technology is below diesel, gas turbine and petrol engines with regard to $CO_2$, $NO_X$, $SO_X$ and noise emissions.

Fig.2 shows a comparison between the overall environmental costs for existing internal combustion engine technology (ICE), electric vehicle technology (EV) and hydrogen fuel cell technology ($H_2FC$).

When all costs are considered: new technology costs, on-going upstream costs (eg, fuel production and distribution) and emission costs, particularly for vehicular applications, fuel cell technology is ahead but it is not a clear-cut conclusion.

In his article on solar power in the March 2002 issue of SILICON CHIP, Ross Tester concluded that most people would not use solar cell technology, no matter how environmentally desirable, unless it meant lower monetary costs for them. There is little doubt that the same conclusion will apply to the use of fuel cells.

**Part 3 in our series on Fuel Cells by GERRY NOLAN**

Now let's look at some of the applications of fuel cell technology.

Developments have gone well beyond the prototype stage for several applications, particularly in space. When aircraft manufacturer Pratt & Whitney won the contract to supply fuel cells for the Apollo program in the early 1960s, their fuel cell design was based on modifications to the Bacon patents for alkaline fuel cells, which are the most efficient at low temperature.

Three units capable of producing 1.5kW, or up to 2.2kW for short periods, were operated in parallel. Weighing around 114kg per unit and fuelled with cryogenic hydrogen and oxygen, these units ran for 10,000 hours during 18 missions without an in-flight incident.

And they produced all the fresh

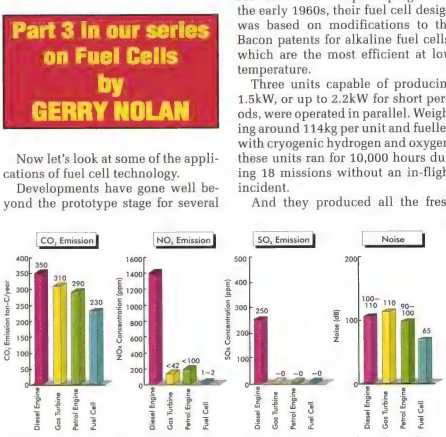



**Fig.1: comparision of carbon dioxode, nitrous oxides, sulphur dioxide and noise emissions between the four main engine types. As you can see, fuel cells win on every measure.**

An installation of five PC 25™ fuel cells at Anchorage in Alaska. *Courtesy of International Fuel Cells LLC*

water for the space missions as well!

Continuing development by International Fuel Cells (which is a division of UTC, the company that P&W became) has meant that the fuel cell stacks used on each shuttle can now provide around ten times the power of similar-size units used in the Apollo craft.

Fuelled by cryogenic hydrogen and oxygen the cells are 70% efficient and have now completed over 80,000 operating hours in more than 100 missions. And there are no backup batteries.

Following the space program success, fuel cells have been used in:

- Stationary power installations for utilities, factories, emergency power for hospitals, communications facilities, credit card centres, police stations, banks and computer installations
- Diverse military applications
- Domestic power supplies for individual residences
- Mobile phones, laptop computers and other personal electronic devices
- Transportation – particularly cars and buses but also in boats, trains, planes, scooters and bicycles, as well as highway road signs
- Portable power for building sites, camping and vending machines.
- Landfills and waste water treatment plants (which are using fuel cells to convert the methane gas they produce into electricity).

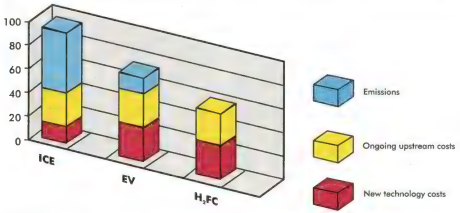



**Fig.2: the environmental costs of new technology versus old for internal combustion engines, electric vehicles and hydrogen fuel cells. Small wonder that fuel cells are regarded as the "green" alternative!**

## Energy supply systems based on fuel cells

Regardless of the type of fuel cell used, they all require a variety of peripheral units to store or convert fuel and convert the DC power generated for AC applications. In addition, they need pumps for fuel and air and ventilation fans to remove heat and water vapour.

Fig.3 represents a generic system based on fuel cells which could be a large utility energy system, a portable power supply or the power pack for a mobile phone – which may not need AC but will still need power conditioning.

Now we'll take a closer look at the way fuel cells fit into each of these various energy system applications.

## Stationary systems

These fall roughly into the three categories: grid-connected; back-up power supplies and domestic installations.

At the time of writing, more than 200 fuel cell systems have been installed all over the world in hospitals, nursing homes, hotels, office buildings, schools and airport terminals. They are either being used to provide

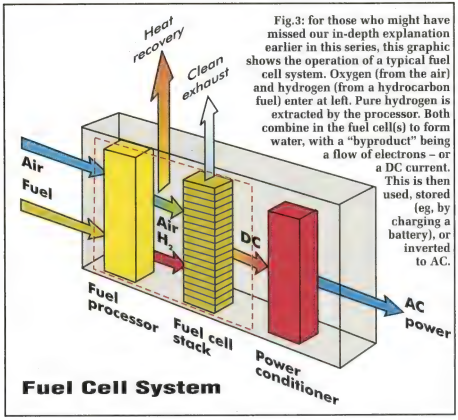



**Fig.3: for those who might have missed our in-depth explanation earlier in this series, this graphic shows the operation of a typical fuel cell system. Oxygen (from the air) and hydrogen (from a hydrocarbon fuel) enter at left. Pure hydrogen is extracted by the processor. Both combine in the fuel cell(s) to form water, with a "byproduct" being a flow of electrons – or a DC current. This is then used, stored (eg, by charging a battery), or inverted to AC.**

primary power or as a backup supply.

The following examples are typical of stationary installations that have been announced in the last year:

- In September 2001, the town of Woking, 40km southwest of London, became the first community to sign up for a commercial fuel cell installation in the United Kingdom.

They contracted with UTC Fuel Cells for a 200kW PC25TM system to provide electricity and heat for the pool in Woking Park recreational centre, as well as electricity to light the park.

- In December 2001, UTC Fuel Cells announced that a PC25TM fuel cell power plant had been installed at Ford Motor Company's North American Premier Automotive Group headquarters in California. The 200kW plant provides 25% of the building's power as well as hot water for the facility.
- Siemens Power Generation Group will build a solid oxide fuel cell (SOFC) power plant with a maximum electrical capacity of 250kW in Hanover, Germany, to be completed by 2003.
- The world's first fuel cell/gas turbine hybrid power plant is now operating at the National Fuel Cell Research Center in Irvine, California. The system features a Siemens Westinghouse solid oxide fuel cell combined with an Ingersol Rand microturbine to produce approximately 190kW of electricity. Early test data show electrical efficiencies of approximately 53%, believed to be a world record for the operation of any fuel cell system on natural gas.

Improvements in the technology could ultimately raise efficiencies to 60% for smaller systems and 70% or higher for larger systems.

## Residential installations

Although mass production will be crucial to bring prices down to make domestic installations practical, with large companies such as International Fuel Cells, Ballard Power and Avista Labs becoming involved, this will eventually happen.

## From fuel processor . . .

Most domestic systems have a fuel processor as part of the fuel cell installation. This includes a fuel reformer, which processes a hydrocarbon fuel such as natural gas, into a hydrogen-rich gas known as reformate. A carbon monoxide (CO) cleanup unit is necessary to reduce the high concentrations of carbon monoxide produced in the process to acceptable levels (under 50ppm).

At the heart of the fuel cell system is the PEM fuel cell stack, which is made up of a membrane electrode assembly sandwiched between two gas diffusion layers with bipolar plates on each side.

The reformate (hydrogen) from the CO cleanup system feeds the fuel side of the fuel cell and the PEM cell generates a DC potential as described last month.

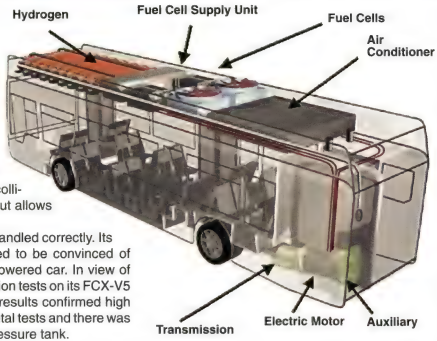
This is fed to the power conditioner which converts the low-voltage DC to

**When we think "fuel cells", until now we've automatically tended to think "big": space shuttles, buses, cars and stationary power generation. But as these pictures show, fuel cells can be downright miniscule! The two pictures at left show just how small fuel cells can be made (yes, that is a pencil!). The third photo, courtesy RoamPower, shows a fuel cell-powered emergency torch, while the fuel cell-powered notebook computer at right (courtesy Ballard Power Systems) is a portent of commercial products planned for release as early as next year and the year after.**

One of the main areas of development of fuel cells in transportation is in public transport buses. In the first article in this series, we showed the outside of the Citaro fuel cell powered bus. Now we can show you the X-ray version so that you can see where all the pieces fit in.

Note the hydrogen supply tanks mounted in the roof. This not only protects them from damage in case of a collision, especially, the hydrogen tanks, but allows for a continuous low floor design.

Hydrogen is very flammable if not handled correctly. Its safety is a factor that people will need to be convinced of before rushing out to buy a fuel cell powered car. In view of this, Honda has run front and rear collision tests on its FCX-V5 prototype, at a speed of 55km/h. The results confirmed high passenger protection safety during frontal tests and there was no hydrogen leakage from the high-pressure tank.




high-voltage AC. Batteries are usually used to ensure that the system copes with power surges from motor start-ups or when peak demand exceeds the system output.

Fuel cell systems, generally with very quick start-up featured, seem to be ideal for primary household supply and as back-up for peak or emergency use or for remote areas.

A very attractive feature is that 'waste' heat can be used to provide hot water or space heating in a home. Since fuel cells operate silently, they are highly preferable to the typical diesel generator on rural properties.

Many of the prototypes being tried in residences use hydrogen extracted from propane or natural gas.

## Transportation

As noted in the first article in this series, much of the development work being carried out with fuel cells is in the transportation industry. More than 100,000 fuel cell powered vehicles are expected on the world's roads by 2004.

As with the stationary fuel cell installations, peripherals are again required.

Fig.3 is a schematic of the main components. With wheel-mounted electric motors, fuel cell technology allows great flexibility in the placement of the various components.

All of the major automotive manufacturers now have at least one fuel cell vehicle under development, including Honda, Toyota, Daimler-Chrysler, GM, Ford, Hyundai, Nissan, Volkswagen and BMW.

Research has shown that the amount of carbon dioxide produced from a small car can be reduced by as much as 72% when powered by a fuel cell running on hydrogen reformed from natural gas instead of a conventional internal combustion engine.

However, it is not enough for the technology to meet tighter legislation on vehicle emissions. It must also pro-

**Fuel cells on (small) wheels: the "MOJITO FC" fuel cell powered scooter showing the fuel cell stack in the pannier. The hydrogen supply is under the pillion seat. At right is the fuel cell pack in a Volkswagen car.**

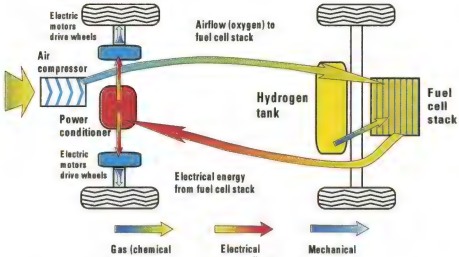



**Fig.4: schematic diagram of the main components of a fuel cell system in a car with electric motors driving the front wheels, or the rear wheels, independently.**

vide transport that offers equivalent convenience and flexibility.

Being able to reach operating temperature rapidly, provide competitive fuel economy and give a responsive performance are all considerations that make the proton exchange membrane (PEM) fuel cells the favourite.

They reach operating temperature (around 800°C) quickly and respond rapidly to varying loads, as well as offering efficiency of up to 60%, compared to the 25% (at best) achieved by internal combustion engines.

PEM fuel cells also have the highest power density, which is crucial in modern vehicle design, and the solid polymer electrolyte helps to minimise potential corrosion and safety management problems.

However, to avoid catalyst poisoning at this low operating temperature ,PEM fuel cells do need an uncontaminated hydrogen fuel.

Still, most major vehicle manufacturers regard the PEM fuel cell as the eventual successor to the internal combustion engine.

## Scooters & bicycles

Manhattan Scientifics and Aprilia unveiled a fuel cell powered concept scooter at the International Paris Fair in April this year. Called "MOJITO FC," the scooter is powered by Manhattan Scientifics' hydrogen fuelled 3kW fuel cell.

It is expected that production models will have a range of nearly 200km and a top speed of at least 60km an hour.

The fuel cell system, including all electronics, valves and fans, weighs slightly less than 6kg, with the fuel vessel weighing only 4.3kg.

Manhattan Scientifics believes fuel cell scooters with optimised drive systems will achieve a higher top speed and quicker acceleration than current vehicles with 50cc and 80cc internal combustion engines.

Manhattan Scientifics and Aprilia previously developed the Aprilia ENJOY FC, a concept fuel cell powered bicycle which received one of Time Magazine's 2001 "Inventions of the Year" awards.

## Portable fuel cell power

In the not-too-distant-future, miniature fuel cells will enable people to talk for up to a month on a mobile phone without recharging the battery. Miniature fuel cells will also power laptops and Palm Pilots for many hours longer than batteries can.

Direct methanol fuel cells powering mobile phones have already been tested and the Casio Computer Company intends to begin selling methanol fuel cells from 2004.

These cells will be able to continuously power a laptop computer for as long as 20 hours, compared with about 3-5 hours from batteries.

The methanol fuel for its fuel cells is expected to cost about 30 cents per litre, which sounds incredibly cheap when you consider the size of the unit that will be using it.

## Landfill treatment

According to the US EPA's Landfill Methane Outreach Program, landfill or biogas has already been tapped at 140 landfills in the USA to provide methane gas through fuel processors directly to fuel cells.

Since a demonstration test in 1992 at the Penrose Landfill, in Sun Valley, California proved successful, fuel cells

**A Plug Power 7kW residential PEM domestic fuel cell installation. Plug Power has been testing the above unit in a home since 1998. Detroit Edison co-founded the company and General Electric agreed in 1999 to distribute and service Plug Power cells. Such support has boosted expectations of a commercial introduction of the domestic fuel cell this year.**

have been installed and are now operating at landfills and waste water treatment facilities in several states in America as well as in Japan.

Groton Landfill in Connecticut, which has been operating since 1996, produces 600,000kWh of electricity a year, with a continuous net fuel cell output of 140kW. In 1997, ONSI (another division of UTC that markets fuel cells) installed a system at the Yonkers waste water treatment plant that produces over 1,600MWh of electricity per year, while releasing only 30kg of emissions into the environment.

The city of Portland, Oregon also installed a fuel cell to produce power using anaerobic digester gas from a waste water facility. It expects to generate 1,500MWh of electricity per year, reducing the treatment plant's electricity bills considerably.

Toshiba has installed fuel cells that run on waste gases at the Asahi and Sapporo breweries and is also targeting local government to sell fuel cell systems that run on gas from sewage, as it has done in Yokohama City.

## Military applications

Fuel cells could provide power for most types of military equipment from land and sea transportation to portable handheld devices used in the field, so military applications are expected to become a significant market for fuel cell technology. The efficiency, versatility, extended running time and quiet operation make fuel cells extremely well suited for military applications.

Clearly, fuel cells would have many advantages over conventional batteries. For a start there would be no need to worry about the logistics of supplying spare batteries. In a similar way, the efficiency of fuel cells for transport would dramatically reduce the amount of fuel required during manoeuvres. Since the 1980s, the US Navy has used fuel cells for deep marine exploration craft and unmanned submarines.

## How much do fuel cells cost?

Ah, the key question! As mentioned at the start of this article, most people won't take up new technology unless they feel that the tangible benefits outweigh the monetary costs.

Fuel cell power plants have been offered for about $6000 per kilowatt installation cost but this would only be acceptable in areas where electricity prices are high and natural gas prices low.

**An Avista Labs Independence 1000 – a 1kW PEM fuel cell.**

A study by Arthur D Little, Inc. predicted that when fuel cell costs drop below $3000 per kilowatt, they will achieve much wider market penetration.

In cars, fuel cells will have to be much cheaper to become commercially acceptable. **SC**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# CIRCUIT NOTEBOOK

**Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.**

## Cheap AC current measurement

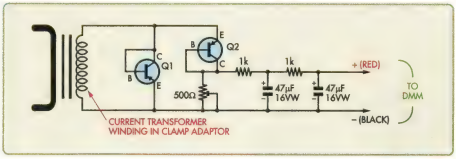
The easy way to measure high AC currents is to use a clamp meter but these are generally quite expensive and cost several hundred dollars at a minimum. Add-on clamp meter adaptors can work well but they only work with digital multimeters which have millivolt AC resolution. This is because the output of most clamp adaptors is quite low; 0.1A = 1mV, for example. This is no good for typical cheap DMMs which have a lowest AC voltage range of 200V.

This circuit can be built into a low cost clamp meter such as the Digitech QM-1565 from Jaycar Electronics (see 2002 catalog, page 189). When dismantling this clamp adaptor, remove the label which has the AC range conversion factors and then undo the two screws to gain access to the inside.

The two cross-connected transistors act like low voltage drop diodes to generate a DC voltage which is proportional to the current in the primary of the clamp adaptor (ie, the circuit under test). The recommended transistors are power germanium types such as ADZ16, AD162, AD149, ADY16, 2SD471, OC16 and OC28. This approach gives lowest voltage drop and good linearity, from 10 to 300A. Schottky power diodes can also be used but the result will not be as linear.

To calibrate, wind 10 turns through the clamp adaptor's jaws and feed a current of 20A through the winding. This is equivalent to a single turn carrying 200A. Set the trimpot to suit your multimeter, normally set to the 2V DC range. Do not calibrate for a low current otherwise accuracy at high currents will be poor.

**Gerard La Rooy, Christchurch, NZ.**



## Low-cost dual power supply

This circuit shows how to symmetrically split a supply voltage using a minimum of parts – one LM380 power amplifier plus two 10µF capacitors. It was originally published in National Semiconductor's AN69 and provides more output power than a conventional general-purpose op amp split power supply.

Unlike the normal power zener diode technique, the LM380 circuit does not require a high standby current to maintain regulation. In addition, with a 20V input voltage (ie, for ±10V outputs), the circuit exhibits a change in output voltage of only about 2% per 100mA of unbalanced load change. Any balanced load change will reflect only the regulation of the source voltage, Vin.

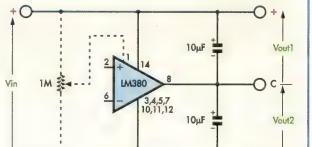
The theoretical plus and minus output tracking ability is 100% since the device will provide an output voltage at one-half of the instantaneous supply voltage in the absence of a capacitor on the bypass terminal. The actual error in tracking will be directly proportional to the unbalance in the quiescent output voltage.

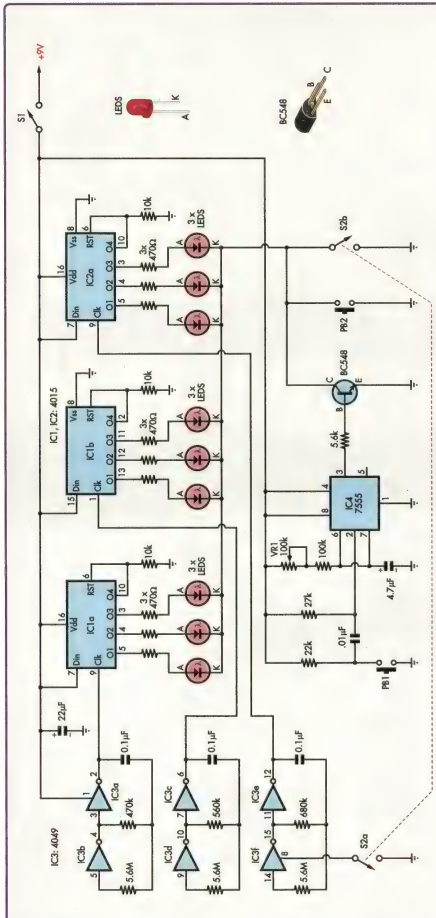
An optional 1MΩ potentiometer may be installed with its wiper connected to pin 1 of the LM380 IC to null any output offset. The unbalanced current output is limited by the power dissipation of the package.

In the case of sustained unbalanced excess loads, the device will go into thermal limiting as the internal temperature sensing circuit begins to function. And for instantaneous high current loads or short circuits, the device limits the output current to approximately 1.3A until thermal shutdown takes over or the fault is removed.

For maximum output power (2.5W), all ground pins (3-5 & 10-12) should be soldered to a large copper area (the LM380 data sheet contains more details).

**National Semiconductor.**






## Quick counter for young children

This circuit is a toy to encourage young children to count. Power is turned on by switch S1, then S2 is closed. This makes nine LEDs flash slowly. S2 is then opened and the LEDs go out. Pressing pushbutton PB1 briefly turns on a random number of LEDs, during which time they are to be counted. The number counted can be checked by pressing PB2 which turns the same LEDs on for as long as needed.

The circuit works as follows: IC3 is a 4049 hex inverter connected as three oscillators running at different rates. It is turned on by closing switch S2a. The clock pulses from IC3 drive both halves of IC1 and one half of IC2, both being 4015 dual 4-stage shift registers.

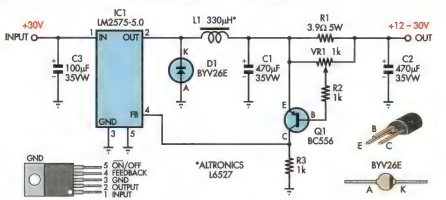
Each shift register has four outputs which go high in order: 1, 1 and 2; 1 and 2 and 3; 1 and 2 and 3 and 4. However, as output Q4 is connected to the reset line of its own half, the shift register resets to zero at this count. Outputs 1, 2 & 3 of all three shift registers are connected to nine LEDs, the cathodes of which go to a common rail. This rail is connected to ground via S2b when switch S2 is closed.

When S2 is opened, the three oscillators stop but a random number of LEDs is still connected to the high outputs of the 4015s. That number can be viewed briefly by pressing PB1 which pulses the 7555 timer in monostable mode, to give a short duration output which drives Q1 and connects the LED cathodes to 0V. The viewing time is adjustable by VR1.

Checking a count is done by pressing PB2 which holds the same LEDs on as long as desired.

The LEDs are set in a 3 x 3 grid with the connections scattered; ie, the first row is not the three LEDs from the first half of IC1. Note that, unlike the usual dice, a number such as 5 can appear in many formats, so pattern recognition is no help. Also note that this is not a nine output true dice – because the numbers do not come up with equal frequency.

**A. Lowe,**
**Bardon, Qld. ($50)**




## Switchmode constant current source

As pointed out in the "Stepper Motor Controller" article in the May 2002 issue of SILICON CHIP, operating a stepper motor using a fixed (constant) voltage supply results in poor torque at high speeds. In fact, stepper motors tend to stall at fairly low speeds under such conditions.

Several approaches can be used to overcome this problem, one of which is to use a constant current supply in place of the more conventional constant voltage supply. A disadvantage of many constant current supplies is that simple circuits are inefficient but that doesn't apply to switchmode supplies such as the circuit shown here.

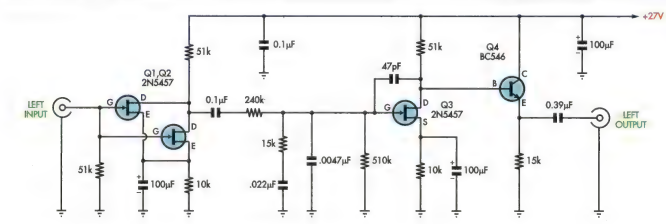
Basically, this circuit is a conventional switchmode regulator adapted for constant current output and is specially designed for stepper motor drivers – although it could be used for other applications as well. The circuit works as follows: IC1 (LM2575T) and its associated components (D1, L1, C1, etc) operate as a switchmode power supply. Normally, for constant voltage operation, the output is connected – either directly or via a resistive divider – back to the feedback input (pin 4) of IC1.

In this circuit, however, Q1 senses the current flowing through R1 and produces a corresponding voltage across R3. This voltage is then fed to pin 4 of IC1. As a result, the circuit regulates the current into a load rather than the voltage across the load.

Only one adjustment is needed: you have to adjust VR1 for optimum stepper motor performance over the desired speed range. The simplest way to do this is to measure the motor current at its rated voltage at zero stepping speed and then adjust VR1 for this current.

The prototype worked well with a stepper motor rated at 80Ω per winding and a 12V nominal input voltage. Some components might have to be modified for motors having different characteristics.

**H. Nacinovich,**
**Gulgong, NSW.($35)**




## Passive RIAA preamplifier

There are two types of preamplifiers for magnetic phono cartridges. An example of the most common type is the one described in the March 2002 issue of SILICON CHIP. It has the RIAA equalisation network in the feedback loop. The second type was previously used in valve circuits which typically had no feedback loop and used passive RC networks to provide the phono equalisation.

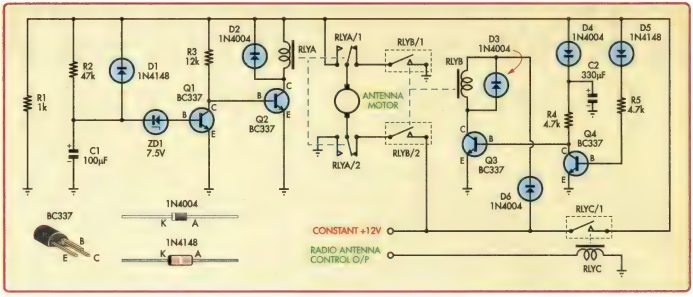
This experimental preamp was put together using inexpensive FETs to compare the performance of these two types of preamp. The first stage, consisting of Q1 and Q2, is a simple FET audio amplifier, where the FETs are connected in parallel to reduce noise.

This is followed by a passive RIAA network consisting of 240kΩ and 15kΩ resistors and their associated 0.1µF .022µF and .0047µF capacitors. Some of the gain loss in the passive network is then made up by FET Q3. It also has a 51kΩ drain resistor and is buffered by bipolar transistor Q4 which is connected as an emitter-follower stage.

All resistors are 1% tolerance metal film types, while the equalisation capacitors are MKT polyester types. Ideally, the Idss of all FETs should be matched for both channels, while the 51kΩ drain resistors should be adjusted so that the drain voltage in each stage is between 13V and 14V, to give symmetrical signal clipping.

The power supply can be three 9V batteries connected in series. Current consumption is only 3mA for the stereo circuit.

**Sam Yoshioka,**
**Kahibah, NSW. ($35)**




## Up/down timer for a power antenna

This up/down timer was designed to control a power antenna on a late-model vehicle. Normally, this vehicle uses a body computer to control the antenna. However, the person who owned the vehicle wanted to install his own high-powered audio stereo system.

The original stereo system was tied in with the body computer and this meant that a separate antenna controller was required for the aftermarket sound system. Also, the power antenna fitted did not have limit switches inside, hence the need for a timed control circuit.

Here's how the circuit works. First, assume that the radio antenna control output is not switched on – ie, the radio is switched off. In that case, relay RLYC will be off and so relay RLYA will also be off, as is the motor.

Conversely, when the radio is switched on, the radio antenna control line switches to +12V. And when that happens, relay RLYC closes its contacts and applies power to the circuit.

As a result, C2 (330µF) quickly charges via D4, while Q4 is biased on via D5 and R5. This ensures that Q3 and relay RLYB remain off. At the same time, Q2 is turned on, thus turning on RLYA and applying power to the motor. This drives the antenna in the up direction.

During this time, C1 charges via R2. When the voltage across the capacitor reaches +8.1V, Q1 turns on via ZD1 and so Q2 turns off and switches off the relay – ie, this gives the "up" timeout.

Using the values shown for C1, R2 and ZD1 gives an "up" duration of approximately six seconds – long enough to fully extend the antenna. D1 discharges C1 (via R1) when the +12V supply is later removed.

When the radio is switched off (or a CD placed into the stereo unit), the radio antenna control output switches back to 0V. This does several things: first, it turns Q4 off and this allows Q3 to turn on due to the stored charge in C2. Q3 and RLYB now turn on for about six seconds – ie, while C2 discharges via R4 – and this switches power to the motor in the opposite direction to drive the antenna down.

Diodes D4 and D5 are there to prevent C2 from discharging back via the circuitry around on Q1 and Q2.

**Peter Howarth,**
**Gunnedah, NSW. ($40)**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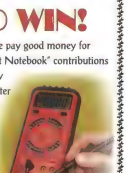

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# SERVICEMAN'S LOG

## If it looks easy, it probably isn't

**Ever noticed how often the fault that looks like an obvious snack, turns out to be a disaster. I made two such assessments this month and both turned nasty. Considering the complexity of modern devices, it's really not wise to stick one's neck out.**

My next door neighbour Leo likes to reinforce the Old Pals Act (OPA) occasionally and get me to "look at" things that don't quite work right. Leo's no slouch for a bloke of his advanced age and hearing, fancies himself as a bit of an engineer and tends to "have a go".

Anyway, one Sunday morning while letting the cat in (at 7am!) – and still in my pyjamas – he asked me to have a look at his Sony ST-E200 stereo tuner. He had already removed the lid and pointing to some transistors (subsequently identified as Q15 and Q16), informed me that the left channel wasn't working because one of these emitter followers was crook.

Some hours later, when I was really awake, I humoured him by looking at it in proper focus. This also meant opening the shop to get the circuit – oh well; I hadn't anything else to do. Regretfully, this ruined my plans to go to church and Mrs Serviceman was unimpressed with Leo's tuner in pieces all over the kitchen table, especially with lamb roast on the menu.

Getting down to details, transistors Q15 and Q16 are conventional muting transistors in parallel but one could cause this symptom. I could confirm this by just disconnecting the collectors but I felt it would be easier to use an audio probe and see if the audio was coming out of IC41 LA1835 (detector and decoder).

I confirmed this; audio was OK on each channel – on pin 21 (R ch) and pin 22 (L ch). From here, each goes to one of two low pass-filters – LPF42 (R ch) and LPF41 (L ch). Audio goes into each LPF on pin 2 and comes out on pin 4. The audio was OK on the input and output of LPF42 (R ch) but was absent on the output of LPF41.

The DC voltages were the same on each and I could see no harm in patching pins 2 and 4 together on LPF41. I now had output from both channels which meant that LPF41 was almost certainly open circuit.

Well, I could have given it back to him like that and I doubt whether he would have heard the difference. But I knew he would have been unhappy with a "bodgie" fix and would have interrogated me as to how I had fixed it. So a replacement LPF41 went into the ordering process first thing Monday morning.

Postscript: believe it or not, this part was not available in Australia and had to be ordered from Singapore. It arrived the next day! The set was soak tested and returned to its owner the next weekend.

Well, that really was an easy one.

(Editor's comment: whatever happened to the policy of changing names to protect the guilty? I'm not too happy about this, especially the comments about age. Life's pretty crook if you can't have a little service job done without having it written up for the whole world to read about it;-)

### A shame to work

The following Monday was a great morning. The sun was up in a cloudless sky and even the kookaburras were telling everyone what a glorious day it was and how good it felt to be alive.

I contemplated over my coffee that it was a shame to have to go to work instead of going to the beach – especially as there wasn't really much on. (At work I mean, not at the beach).

I felt that today would be a good time to sort out some old stock and fix up some odd jobs left lying around. And so I turned to a couple of Panasonic TV sets that had been put aside for a very long time and needed investigating.

One was a 1990 TC-2670S M15D, which had been abandoned due to an horrendous intermittent fault of no video when hot (it was invariably OK when cold) and no sound.

The other was a 1992 TC-63A61 M16M, which I had been given a couple of years ago with the picture tube (M63JUA07X) having no red. Its cathode was completely stripped and I'd had no luck in obtaining a replacement because 63cm sets are no longer a popular size – it's now usually either 59cm or 68cm. The other problem was that the tube is an FST (Flat Square Tube).

Well, today was the day I was going to resolve these and hopefully other long standing problems.

The plan was to look at the older M15 and see if I could fix it with information I had acquired since abandoning it. If that turned out to be unsuccessful, my strategy was to try to fit the M15 picture tube into the later M16 set.

The audio problem was easily fixed. There was no 18V at IC2301 pin 1 AN7158N, due to R827 (0.22Ω) being open circuit.

It took longer to fix the picture failure when hot. I started with the usual suspects, namely R525 (100kΩ – check this out of circuit or waste a lot of time) and Q601 (UN1111, DTA114EA), but these were OK. The latter, by the way, can be replaced with a general purpose PNP transistor such as a BC558, with 10kΩ in the base and 10kΩ from base to emitter.

In the end, the fault turned out to be just faulty joints and some corrosion. The picture wasn't bad but the 12-year old set was corroded and dirty and very much the worse for wear.

Finally, I made a decision – I would scrap this set (with a good working chassis) for parts and transplant the tube to the later model set.

## Removing the tube

Removing the tube was relatively easy, except for the time needed to remove the case. The tube is so large and heavy and the cabinet is very light and tends to move. Also, there is very little room for one's fingers to get a grip around the rimband. I put a plastic lunchbox underneath to take the weight of the tube as it came away from the four studs and the case supports. I could then rearrange my grip and get a better purchase.

I made the mistake of trying to put the replacement tube in the M16 cabinet face down instead of leaving it vertical (the empty cabinet was just too flimsy and kept moving). The result was that although I fitted the tube in, it was 12mm out but stuck fast. When I eventually moved it into the correct position, it fell heavily those last 12mm onto its face but a quick inspection later on indicated that everything was probably OK.

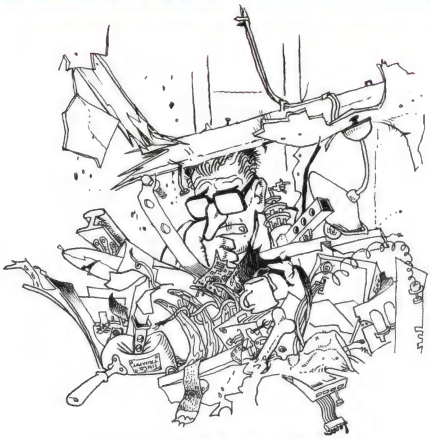
I was going to replace the deflection yoke but the one already on the tube looked identical to the original. Not only that but the plug fitted straight into the DY position. Also, the wire colours matched. I refitted the chassis and after a final check, switched the set on.

It tried to come on but then stuck in standby. What could I have done wrong? Well, lots as it turned out.

I removed D560 and switched on. Smoke rose out of the power supply board (D). It took a couple of hours to work out what I had done. As it turned out, the M15D deflection yoke (Part No: TLY15459F) differs from the M16M yoke (Part No: TLY15493F). Not only that, the DY plug is wired differently despite the fact that the

### Items Covered This Month

- Sony ST-E200
- Panasonic TC-2670S M15D chassis
- Panasonic TC-63A61 M16M chassis
- Philips 14PT132A/75R L7.01 chassis
- Sony KV-3400MAS SCC-C91C-A GP-2A chassis



I TRIED TO WORK OUT WHAT DAMAGE HAD BEEN CAUSED...

wire colours are the same.

As a result, high-voltage horizontal pulses were injected into the output of the vertical IC (IC452, LA7838), destroying it and causing R570 and R451 to overheat and smoke. At the same time, additional current flowing through R578 in series with R570 caused Q557 to switch on and so the protection circuit was switched on.

But this was only the beginning. It took two ICs to find out that D460 (MA4360M), a 36V zener, was also short circuit.

Finally, after it was all fixed and the set was switched on, there was only a blurred smudge on the screen, a noise and the smell of burning. This turned out to be a fracture suddenly appearing in the tube neck under the yoke, with arcing everywhere. The tube was kaput!

I had waited a couple of years to replace this tube and I was now determined to fix the set. I tried all my colleagues (again) and was lucky to find one who had just scrapped an M15LW chassis, so I took the tube back and fitted it into the M16M, this time with a lot more care.

I was also careful while transplanting the deflection yoke and in fact everything associated with the tube. In the process, I removed all the old parts, including the chassis strap and degaussing coils, and put them on a shelf above the set, behind some aerosol cans.

The new tube worked well but when I reached up for a can of CRC 2-26, the old chassis strap got caught and fell straight onto the M16M chassis beneath. Unfortunately, it was switched on at the time and there was a small spark as I dashed for the main power switch.

After removing the offending chassis strap, I tried to work out what damage had been caused. The strap was nearly half a metre long and could have touched the righthand loudspeaker as well as the high voltage power supply.

On switch on, I confirmed there was now no audio and R819 (0.47Ω) in the 25V rail was open circuit. Replacing it caused the new one to smoke very quickly so I replaced the sound output IC (IC2301 MC13500T2) but there was still no sound and R819 was still getting hot.

Next, I measured the rail and found that it was only 14V when it should have been 25V. However, when I desoldered pin 9 of the audio IC, the voltage rose to its correct value.

I had fitted a TA8200AM audio IC instead of the MC13500T2 which should have been OK. So was there any modification required? I spent a lot of time on this red herring before I woke up that the lefthand loudspeaker voice coil was short circuit – not the righthand one, as I had suspected.

Unfortunately, the speaker is a custom 8Ω 10W oval type, so it will be difficult to get an exact match. In the meantime, I've substituted a similar unit which fitted after a session with the electric drill.

And what is the moral of this story? If it starts out to be a beautiful day and if the planned exercise looks easy, it can still end up like the pits.

## Philips portable

I don't get many portable TV sets these days, as they are so cheap to buy now. Occasionally, they do arrive and when a 1997 Philips 14PT132A/75R (L7.01 A chassis) came in with no audio, I assumed it would be a simple fault. I mean, a TV set with no audio – how hard can that be? There was no audio from the loudspeakers or earphone socket on either TV or AV input.

This particular set also had Teletext and "SMART" controls which give a selection of preset Picture and Sound positions to enhance the type of program selected.

To get into the SDAM (Service Default Alignment Mode), I needed to short M24 and M25 and switch on. However, there were no error codes. Standby leaves this mode.

I measured loudspeaker continuity right back to pins 6 and 8 of IC 7120, a TDA7065B 3W audio amplifier. I measured 16V (Vcc) to pin 2 and an audio probe showed that audio was getting to the pin 3 input. That only left pin 5, the DC volume control – it had no voltage on it at all.

With the set switched on, I connected my old analog multimeter (on

the x 1 resistance range) between pins 5 and 4 (chassis). Suddenly the room was filled with sound.

The DC volume is controlled by pin 2 of the microprocessor (IC7601, SAA5290ZP/072) and is connected by R3630, a 10kΩ SMD resistor. However, there are 11 other components hanging off this line, mostly diodes, capacitors and resistors.

Using a digital multimeter, I measured the impedance to chassis and it read over 3MΩ. So no short circuit, I thought. That left 11 components to check apart from the two ICs – a piece of cake.

First, I changed the audio output IC (it has only 9 pins), in case an internal diode protection circuit was dragging the voltage down. It wasn't.

Next, I measured 1V on pin 2 of IC7601 but nothing on the other side of R3630. The voltage on pin 2 varied from 0-3.3V, depending on the volume setting. I checked R3603 from the 5V rail to pin 2 as 8.2kΩ and R3630 was correct at 10kΩ.

I then disconnected the three diode clamps on the line and replaced the two electros. I also measured the remaining resistors – everything checked out OK. So where was the voltage being held down?

The remaining components were all surface mount devices (SMD). They are not only very small but are also glued to the PC board, making them difficult to remove. I tried heating and freezing them to see if any responded but nothing showed up.

Finally, I desoldered pin 5 of IC7120 from the board and soldered this pin (only) to a jumper lead connected directly to pin 2 of the microprocessor. Finally, I had voltage and sound which was now controllable.

That led me to my chief suspect – SMD capacitor C2121 (0.22µF). Even though I had checked the resistance of this capacitor several times in circuit, I now found after removing it that it measured only 586Ω. This was definitely the culprit but why didn't it measure low before?

One possibility is that this device might have been intermittent and only showed its true – and permanent – leakage after the stress of being removed.

Or was I deceived by the meter? Digital meters are fundamentally more accurate and have both advantages and disadvantages compared to analog types. One advantage is that they can often accurately measure component values in circuit, since the voltage they apply is too low to switch on active components such as diodes and transistors.

On the other hand, the measuring voltage from a digital meter is too low to place the component being checked under stress. Older analog meters use 9V or 22V batteries and can detect leakage better because components are being checked under more realistic working conditions.

## A big Sony

An 80cm Sony TV monitor was dropped in for repair. I say "dropped" but I don't mean it literally – this set weighs in at 74kg and something would certainly have broken if it had really been dropped.

I had never previously seen this model – a KV-3400MAS SCC-C91C-A, using a GP-2A chassis. It was owned by a recording studio and someone had obviously had a look at it, as some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boards were loose inside and some metal covers had been removed. All I was told was that it was dead and they asked if I could "please, please fix it ASAP". Fortunately, a service manual was supplied with the set.

The section where the covers had been removed was the power supply (F1) and I could see that all the electros had been replaced recently by someone who knew what he was doing; the work was clean and the soldering good. However, after a few resistance checks, I confirmed that PS653, a 2.7A IC link fuse that looks like a two-legged transistor, was open circuit. This is the source of the 15V B line going to CNO20 (pin 1) on the D Deflection Board and on to IC503 (STR90120), a large switchable 12V IC regulator.

With all the modules plugged back in, the symptoms at this stage were that the set would try to come on, with red LED D41 on the front indicator panel H coming on for a few seconds; otherwise the set was dead. There was no sign of distress anywhere else, which I thought might have caused the blown fuse.

My approach now was to follow the two rails, looking for something that was drawing too much current. I disconnected the modules one at a time as I progressed and when I disconnected the B Chroma Decoder board, the set fired.

Elated, I followed the 12V everywhere on the B board, desoldering devices everywhere in an attempt to find out what was causing the set to die. Finally, I reached the Comb Decoder IC (1310) and disconnected the 9V rail (via Q1360 from the 12V rail) to pin 1. Once again the set fired. However, after spending a lot of time up and down this path, desoldering and resoldering everything, I finally realised that the fault was intermittent and wasn't due to anything on this board.

It took a while to work out what was going on. Something was activating the protection circuit and switching the set to standby. Because of the PS653 fuse failure, I had assumed that it was a short circuit on the 12V or 15V rail that was responsible but that turned out to be a red herring.

I established that there was 135V on the horizontal output transistor (Q804) collector which was correct but the 135V on the horizontal drive transistor (Q805) was not right. Instead, it meant that this transistor was cut off and I found that it had no horizontal pulses coming in from the jungle IC (IC501, TEA2028B). However, the oscilloscope showed me it was trying to come on momentarily.

Among others, the circuit that interested me was the safety circuit involving Q806 and Q807 from pin 4 of the horizontal output transformer to pin 28 of IC501. Transistor Q806 detects the current flowing through R843 to the horizontal output stage and if it's excessive, applies voltage through inverter Q807 and switches off the oscillator in the jungle IC.

It was here that I found the circuit in the service manual was quite different from the one in the set. In particular, R842 turned out to be a zener diode but it checked out OK.

The safety circuit wasn't being activated, the collector of Q806 was correct at 0V and Q807 seemed correct too. Desoldering pin 28 of IC501 restored the picture. So what was happening between that and the collector of Q807? I traced the circuit and found it went near a mounting screw. Careful examination revealed a hairline fracture across seven PC tracks and it was this that was causing the intermittent fault.

The fracture was extremely fine and the tracks extremely narrow, so it took a lot of effort to solder tiny links across them. I was just completing this when I had an attack of stupidity. I had been using solderwick on and off on all the work I had been doing and when not using it, I had just placed it on top of the power supply which still didn't have its metal covers replaced.

When I had finished, I tidied up and removed the tools and reassembled the boards – but I hadn't noticed the solderwick.

I switched the set on and there was an almighty bang from the power supply. I immediately switched off. It was fairly obvious the copper wick had shorted out the power supply but what was the extent of the damage?

The violence of the short had melted two welts on the big aluminium heatsink. I removed the power supply and checked it all carefully – but amazingly could not find any fault. The copper braid had shorted the live side of the chopper transformer to the chassis side and the main circuit breaker had saved the day.

I reassembled everything with much greater care and switched on. This time the set came on properly. I connected video and audio and the picture and sound were good.

So that was it – but I was lucky with the solder wick incident. **SC**

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See catalogue page 193 for full details.

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  SW: 5.95 - 21.85 MHz (8 Bands)
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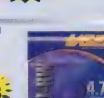

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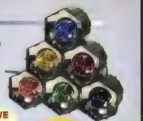

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**WAS $3.25ea**
**THIS MONTH BUY 2 FOR $4**
**SAVE $2.50**
**2 for $4**

## 100W Soldering Gun with Pilot Light

Ever tried to solder large battery loop terminals or TV chassis with a standard soldering iron? The heat up time can take forever, this solder gun will give you 100watts of power in seconds, allowing you to tackle the big jobs with ease.
Cat. TS-1425
**$29.95**

**THIS MONTH RECEIVE A 200 GRAM (NS-3010) ROLL OF SOLDER FOR FREE. WORTH $6.95.**

## Panel Meter Savings

### 3.5 Digit LCD Panel Meter

Cat. QP-5570
**WAS $23.95**
SAVE $4
**NOW $19.95**

### 3.5 Digit L.E.D. Panel Meter

Cat. QP-5580
**WAS $26.95**
SAVE $4
**NOW $22.95**

## Engine Analyzer Dwell Tacho DMM

Make servicing your car a easier with this compact automotive DMM. Measures RPM, dwell angle, voltage, amps and resistance The instruction book also guides you on how to check many other aspects of automotive servicing. For full details see page 189 of the 2002 catalogue.
Cat. QM-1440
**WAS $78.95**
SAVE $20
**NOW $58.95**

## Electronic Flouro Starter

Starts fluorescent lamps in under a second, and increases the life of the tube up to 3 times. Standard size fitting.
Cat. SL-2758
**NORMALLY $11.25ea**
SAVE $3.75
**Buy 3 for $30**

## Programmable LCD Display Soldering Station

**Designed in Germany**

Temperature is precisely controlled and can be set in increments of 1°C across the range of 150°C to 450°C. Up to 3 preset temperatures can be programmed and instantly selected. Each temperature preset is shown on the LCD control panel as well as the current tip temperature.
Cat. TS-1400
**WAS $249**
SAVE $50
**NOW $199**

## 4 Door Central Locking Kit

Do it yourself and save. Supplied with 4 door actuators, wiring and all hardware required. Can be wired to your alarm to give you keyless entry or you can buy our keyless entry kit (LR-8831) for only $79.95 more.
Cat. LR-8830
**WAS $59.95**
SAVE $10
**NOW $49.95**

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## Super Loud 20 Watt 12VDC Speaker Siren

Originally manufactured as a car alarm siren, and features an adjustable mounting bracket and is moulded from hi impact ABS plastic making it suitable for home, automotive or industrial use. Priced well below normal. Cat. LA-5265

**WAS $29.95** SAVE $5 **NOW $24.95**

## Universal Battery Charger 240V

Charges NICAD and NI-MH batteries. Automatically discharges the cell, then fast charge them, then switch to trickle charge. Suits AA, AAA, C, D and 9V batteries, (9V not fast charged).
Cat. MB-3500

**WAS $59.95** SAVE $10 **NOW $49.95**

## Lithium Ion Camcorder Charger

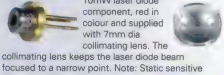
Got a SANYO, PANASONIC, JVC, CANNON OR SHARP late model camcorder? This microprocessor controlled charger is designed to quickly charge 3.6 & 7.2 volt Lithium Ion camcorder batteries in as little as 4 hours, (up to twice as fast as an ordinary charger). Supplied with AC adaptor for home use and a cigarette lighter lead for in car charging.
Cat. MB-3585 **WAS $79.95** SAVE $10 **NOW $69.95**

## 1.8AH Sub C Nicad - Solder Tags

Cat. SB-2468

**WAS $6.95ea** SAVE $0.70 **NOW $6.25ea**
**BUY 10 $5.50ea**

## 10mW Laser Diode plus Collimating Lens



10mW laser diode component, red in colour and supplied with 7mm dia collimating lens. The collimating lens keeps the laser diode beam focused to a narrow point. Note: Static sensitive

| | |
|---|---|
| •Threshold Current: | 30mA |
| •Operating Voltage: | 2.3 volts |
| •Optical Power: | 10mW |
| •LD Reverse Voltage: | 2 volts |
| •PD Reverse Voltage: | 10 volts |
| •Size: | TO-18 (5.6mm dia) |

Cat. ZD-1954 **NOW $19.95**

## 35A 400V Bridge

Cat. ZR-1324
**WAS $4.95ea**
**NOW $3.95ea**
**BUY 10 $3.45ea**

## Switchmode Plugpack

This regulated plugpack is switchable and will provide 9,12,15V @ 1.5A, 18 & 20 @ 1.2A and 24V @ 1Amp. Supplied with 7 different DC plugs.
Cat. MP-3420
**WAS $49.95** SAVE $10 **NOW $39.95**

## Light Duty Speaker Cable 30m Roll

SAVE $2
Cat. WB-1703
**WAS $10.95**
**NOW $8.95**

## RG59 75OHM Gas Injected Coax 30m Roll

SAVE $7
Cat. WB-2005
**WAS $26.95**
**NOW $19.95**

## 6 Core Alarm Cable 30m Roll

Cat. WB-1593
**WAS $24.95** SAVE $6
**NOW $18.95**

## LED Green 5mm 6000MCD

Cat. ZD-1779
**WAS $7.80** SAVE $1.85
**NOW $5.95**

## NEW LED's

**Low Prices**

**3mm 3500MCD Green LED**
Cat. ZD-1991
$3.95ea — Buy 10 $3.45ea

**3mm 2500MCD Blue LED**
Cat. ZD-1992
$2.95ea — Buy 10 $2.60ea

**3mm 3000MCD White LED**
Cat. ZD-1990
$2.95ea — Buy 10 $2.60ea

**5mm 2000MCD Blue LED**
Cat. ZD-1998
$2.50ea — Buy 10 $2.21ea

**5mm 3000MCD Blue LED**
Cat. ZD-1999
$3.50ea — Buy 10 $3.15ea

**5mm 6000MCD White LED**
Cat. ZD-1997
$3.95ea — Buy 10 $3.15ea

## 7812 12V Regulators

Cat. ZV-1512
**WERE $1.20ea**
**NOW $1.00ea**
**BUY 10 $0.90ea**

## 7805 5V Regulators

Cat. ZV-1505
**WERE $1.20ea**
**NOW $1.00ea**
**BUY 10 $0.90ea**

## Discontinued Multimeter Sellout

Very Limited quantities

**Only available from Jaycar stores**

### 32 Range Large LCD Display

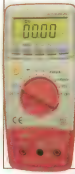
Volts, amps (10A max), DC&AC, ohms, transistor test, diode test & continuity.
Cat. QM-1300
**WAS $55 SAVE $15.50**
**NOW $39.50**

### 30 Range DMM Big LCD

Features lockout shutters, capacitance, temp, continuity, backlight, and data hold.
Cat. QM-1301
**WAS $69.95 SAVE $20**
**NOW $49.50**

### DMM Autorange

Features lockout shutters, capacitance, frequency, continuity, backlight and data hold.
Cat. QM-1532
**WAS $79.95 SAVE $20**
**NOW $59.95**



### DMM Autorange Double Insulated

Features 3999 count, duty cycle, relative measurement, data hold and backlight.
Cat. QM-1540
**WAS $89.95 SAVE $30**
**NOW $59.95**

## Multi Network Tester

This tester is designed to quickly test UTP/STP/Coaxial/Modular netwprk cables by auto scanning the wires for continuity, mis-wiring and polarisation. Supplied in protective vinyl case.
Cat. XC-5081
**WAS $139 SAVE $20**
**NOW $119**

## SLA Battery Chargers

These are 240V plug in power packs for charging SLA batteries. These are fully automatic and they switch to trickle charge when the battery is charged. An LED indicates charge state.
2 models available

### 6 VOLT CHARGER

Cat. MB-3516
**WAS $32.95 NOW $24.95** SAVE $8

### 12 VOLT CHARGER

Cat. MB-3517
**WAS $32.95 NOW $24.95** SAVE $8

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## Talking Fridge Magnets

We often come across novelty items in our search for new & interesting products, but seldom have we seen such a large range of unusual talking fridge magnets. Each one of these little beauties has a recorded message or sound that plays back when activated. For instance, the cigarette packet magnet says "No Smoking" and the garbage can says "Honey, put out the trash". There are bottles that make pouring sounds and even a toilet shaped magnet that makes flushing noises. With so many to choose from, you are sure to find one to tickle your fancy. See 2002 catalogue page 338 for full range & details.

**Briefcase** Cat. LM-1700; **Fax Machine** Cat. LM-1712;
**Filing Cabinet** Cat. LM-1714; **Public Phone** Cat. LM-1726;
**Fridge Message Clip** Cat. LM-1716; **Touch Phone** Cat. LM-1728;
**Beer Bottle** Cat. LM-1706; **Notebook Computer** Cat. LM-1718;
**Poker Machine** Cat. LM-1730; **Photo Copier** Cat. LM-1708;
**Lagerbrau** Cat. LM-1720; **Toilet** Cat. LM-1732;
**Diet Scale** Cat. LM-1710; **Memory Phone** Cat. LM-1722;
**Truck Memo Clip** Cat. LM-1734

**$14.95 each**

## Contour Travel Alarm Clock / Thermo

Lending its shape toward amorphous styling for a modern distinctive look, this travel alarm clock blends style with features using a blue EL backlit screen which displays time, day, date and temperature with large easy to read digits.
Cat. XC-0227

**$39.95**

## Alarm Clock / Thermo

This elegant desk clock features a blue EL backlit display for easy night viewing and displays time, day, date, month, and temperature.
Cat. XC-0229

**$29.95**

## Mini Pocket Scale

Not much bigger than a packet of cigarettes, with a maximum capacity of 500grams and a resolution of 0.1gram. Features tare function, low battery warning, auto power off and will measure in ounces too. . Measures 140(L) x 80(W) x 30(H)mm.
Cat. QM-7247

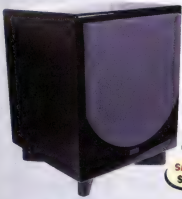
**$199**

## 2 Kg Digital Kitchen Scale

Ideal for kitchen or mail room use, these scales will measure up to 2kg with a resolution of 1g. The scales have a 'tare off' function which means that you can disregard the weight of the mixing bowl and measure just the contents as you put them in.
Cat. QM-7244

**$59.95**

## Piano Finish 10" 120WRMS Active Subwoofer 120WRMS



RESPONSE

Got a home theatre setup? This stylish unit presents a classy polished black finish and uses a 10" high compliance subwoofer and an inbuilt amplifier for great bass performance. The amplifier features automatic switch on/off, RCA and speaker level line input & output, variable crossover, 0-180phase switch and sensitivity control.
350 (W) x 450 (H) x 360 (D)mm. Cat. CS-2454 **WAS $499**

**SAVE $50**

**$449**

## 240W Active Home Subwoofer Amp Module

Building your own subwoofer? This amp module will deliver 240WRMS into 4 ohms and 150WRMS into 8 ohms. Features RCA and speaker level input and output, variable phase, crossover and sensitivity controls.
Cat. AA-0501 **WAS $369**

**SAVE $50**

**NOW $319**

## 12 Hour Clock

Ideal clock for houses, offices, anywhere! A very easy to read display with large digits and quartz timing mechanism.
Cat. XC-0110 **WAS $12.95**
Limited stocks

**NOW $9.95**

**SAVE $3**

## Ultrasonic Cleaner

This machine uses an ultrasonic transducer to create millions of microscopic cleaning bubbles that reach deep into cracks and holes to remove dirt and grime. Ideal for cleaning jewellery, glasses, razors, switches PCB's etc, etc. Built in 15min timer. Not designed for commercial use.
Cat. YH-5400 **WAS $169.50**

**NOW $159.50**

**SAVE $10**

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# Venom SUBWOOFERS

Representing unparalleled value for money, the Venom series of subwoofers will amaze both car audio and home cinema enthusiasts with their long list of features and bang-for-buck performance. Being 4 ohm you can use them in the car or at home, as many household amplifiers will accept 4 ohm loads. Each speaker features pressed steel baskets, ultra stiff doped paper, super wide 1" butyl rubber surround, double magnet assembly and vented pole piece, all adding up to great value that you just don't see very often.

## 8" 4 Ohm Subwoofer

NEW

**Specifications**

- Nominal impedance: 4 ohms
- Power rating: 100WRMS
- Sensitivity at 1W@1m: 88.35dB
- Resonant frequency (Fs): 35.71
- Total Q factor (Qts): 0.384
- Equivalent volume (Vas): 42.87
- X max: 5mm
- Typical application: (vented box)
- Box volume: 29.7Lt

Cat. CS-2340

**$49.95**

## 10" 4 Ohm Subwoofer

NEW

**Specifications**

- Nominal impedance: 4 ohms
- Power rating: 150WRMS
- Sensitivity at 1W@1m: 92.02dB
- Resonant frequency (Fs): 37.53
- Total Q factor (Qts): 0.488
- Equivalent volume (Vas): 106.6
- X max: 5mm
- Typical application: (sealed box)
- Box volume: 33.29Lt

Cat. CS-2342

**$79.95**

## 12" 4 Ohm Subwoofer

NEW

**Specifications**

- Nominal impedance: 4 ohms
- Power rating: 180WRMS
- Sensitivity at 1W@1m: 87.85dB
- Resonant frequency (Fs): 31.27
- Total Q factor (Qts): 0.520
- Equivalent volume (Vas): 69.49Lt
- X max: 5mm
- Typical application (sealed box)
- Box volume: 26.11Lt

Cat. CS-2344

**$99.95**

## 15" 4 Ohm Subwoofer

NEW

**Specifications**

- Nominal impedance: 4 ohms
- Power rating: 250WRMS
- Sensitivity at 1W@1m: 88.48dB
- Resonant frequency (Fs): 25.65
- Electrical Q factor (Qms): 0.578
- Total Q factor (Qts): 0.497
- Equivalent volume (Vas): 150.7Lt
- X max: 5mm
- Typical application (sealed box)
- Box volume: 49.16Lt

Cat. CS-2345

**$129.95**

## Economy Car Alarm

EQUATOR

Even though we've dubbed this alarm an economy model, it is still feature-packed and will provide thorough protection to any vehicle. Features include instant triggering, Immobiliser, Door lock/unlock, Flashing LED, Passive arming, Trigger memory report & the list goes on.

WHAT YOU GET

- Electronic black box controller
- 2 transmitter key-fob learning remote controls
- Shock sensor
- Boot pin switch
- Mini size siren
- Ignition cut-out relay
- Wiring looms

Cat. LA-8985

**$119.50**

## 6.5" XL Split / Coaxial Speaker Combination

RESPONSE

The XL-Response combination split/coaxial speakers have a unique way of mounting the tweeter. The adjustable 20mm dome tweeter mounts on the woofer just like a regular coaxial speaker. With a quick twist, you can remove the tweeter and put the supplied phase plug in its' place, giving you a typical split speaker system. Supplied with tweeter mounting brackets, grilles, mounting hardware, 12dB/oct 2-way crossovers and wiring. Power handling 70 watts (40WRMS) system power.

Cat. CS-2296

**$119Pr**

## RESPONSE 15" Subwoofer

NEW

15" subwoofers are known for their huge bass abilities, and this one certainly doesn't disappoint, to put it simply, this speaker is a BEAST. This speaker features a cast aluminium frame, graphite coated paper cone, butyl rubber surround, double magnets, vented pole-piece and chrome plated magnet cap. Build quality that you normally see in speakers twice the price. •Nominal impedance: 4 Ohms •Power rating: 300W RMS •Sensitivity at 1W@1m: 92.0 SPL •Resonant frequency (Fs): 24.38Hz •Total Q factor (Qts): 0.295 •Equivalent volume (Vas): 187.9Lt •Voice Coil Diameter: 75mm •X max: 11.5mm •Typical application (vented box) •Box volume: 56.42Lt

Cat. CS-2350

**$349**

## 2GA OFC Ultra High Current Power Cable

NEW

160 amps. rated.
Dia:12mm.
Resistance @ 20°C:0.0007Ω/mt.
Strands: 145 x 19 / 0.12mm.
RED Cat. WH-3070
BLACK Cat. WH-3072

**$12.95 /metre**

## Fuses to Suit Platinum Distribution Block

All gold plated for low resistance. Supplied in packs of two. Sizes available:

**20A** - Cat. SF-1940, **30A** - Cat. SF-1942, **40A** - Cat. SF-1944, **60A** - Cat. SF-1946, **80A** - Cat. SF-1948, **100A** - Cat. SF-1950, **120A** - Cat. SF-1952.

**WERE $9.95 Pk2**

AMP-KING

SAVE $2

**NOW $7.95 Pkt 2**

## Platinum Battery Terminals

**4 WIRE** Accommodates one 2G, one 4G and two 8G cables via compression fittings.
**Positive** Cat. HC-4054 **Negative** Cat. HC-4056
**WERE $32.95ea NOW $24.95 SAVE $8**

**Hard Protective Cover to Suit** Cat. HC-4057
**WAS $6.95 NOW $4.95 SAVE $2**

**3 WIRE** Accommodate one 4G and two 8G cables via compression type fittings.
**Positive** Cat. HC-4060 **Negative** Cat. HC-4052
**WAS $26.95ea NOW $21.95 SAVE $5**

**Hard Protective Cover to Suit** Cat. HC-4053
**WAS $4.95 NOW $3.95 SAVE $1**

## Platinum Fused Distribution Blocks

**2 Way** Accepts one 4G in and two 8G out via compression fittings. Suits gold maxi fuses.
Cat. SZ-2084 **WAS $19.95 NOW $15.95 SAVE $4**

**4 Way** Same as the above fuse block, accepting one 2G and two 4G inputs split to four 8G outputs. Suits gold maxi fuses. Cat. SZ-2086
**WAS $29.95 NOW $23.95 SAVE $6**

OVERNIGHT DELIVERY AVAILABLE

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## DISCONTINUED KIT BOARD SELLOUT

**We have a quantity of printed circuit boards from old kits. The prices listed are half our normal selling prices. Buy any 5 & deduct another 30%.**

Jaycar ELECTRONICS No 1 For Kits

## Only available from Techstore Mail Orders. Not available from Jaycar stores.

| CAT NO | QTY | BOARD NO | DESCRIPTION | ISSUE | PRICE |
|---|---|---|---|---|---|
| EC7070 | 10 | 91VC11 | KARAOKE MIXER | Nov-91 | $3.90 |
| EC7075 | 2 | 920SC2 | SINE SQUARE WAVE GENERATOR | Mar-91 | $6.15 |
| EC7093 | 6 | 93PS9 | 40V 3A LAB POWER SUPPLY | Dec-94 | $13.35 |
| EC7097 | 1 | 94MX981 | MIDI BREAK OUT BOX | Feb-94 | $4.10 |
| EC7104 | 8 | 94LT8 | ACTIVE SUB CROSSOVER SHORT FORM | Sep-94 | $4.75 |
| EC7113 | 1 | 96EC607 | LCD DRIVER ECG KIT | Jul-95 | $8.75 |
| EC7121 | 1 | 98ESR1 | ESR LOW OHMS METER | Jul-95 | $8.75 |
| EC7124 | 106 | EA96SB8A3 | H-BRIDGE/OVERPOWER BRIDGE ADAPTER | Dec-96 | $7.00 |
| EC7125 | 3 | 96IR7VC | REMOTE CONTROL FOR PRO 4 PREAMP | Dec-96 | $5.65 |
| EC7127 | 88 | EA 96LFT | LINE FILTER CONDITIONER | Jul-96 | $5.65 |
| EC7130 | 7 | 96BS10B | PC BUS SLEUTH-RO / DMA LED BRD | Oct-96 | $6.75 |
| EC7131 | 3 | 96PCI011 | 24 LINE I/O CARD | Nov-96 | $16.45 |
| EC7133 | 3 | 96PR12B | PRO SERIES 4 PREAMP SWITCH BRD | Dec-96 | $7.00 |
| EC7139 | 3 | 97CEM2 | CRITICAL SYSTEM ALARM | Mar-97 | $4.35 |
| EC7140 | 2 | 97PU9 | REMOTE POWER UP | Jun-97 | $8.35 |
| EC7143 | 1 | 97AFS08 | AUDIO FREQUENCY SHIFT | Mar-97 | $11.25 |
| EC7145 | 2 | 97LCT1 | LINE CARRIER LINK | Nov-97 | $7.85 |
| EC7152 | 1 | 98LCA1 | LINE CARRIER ADD ON | Mar-98 | $2.75 |
| EC7153 | 1 | 98LCC1 | LINE CARRIER ADD ON | Mar-98 | $2.25 |
| EC7154 | 2 | 98BT02 | CABLE BREAK FINDER | Feb-98 | $3.10 |
| EC7157 | 1 | 98VFW4 | VIDEO FADER WIPER | Apr-98 | $3.90 |
| EC7158 | 9 | 98PPU5 | PHANTOM PSU | Jun-98 | $2.15 |
| EC7311 | 3 | ETI1521 | 4 SECTOR HOME ALARM | May-99 | $14.75 |
| EC7513 | 204 | AEM1502 | FM MINDER BUS | Mar-88 | $3.35 |
| EC7622 | 1 | SC5-1-588 | HIGH-ENERGY IGNITION | May-88 | $5.00 |
| EC7633 | 1 | SC06-1-1088-1 | MINI MITTER | Oct-88 | $4.75 |
| EC7637 | 7 | SC9109P22 | KNIGHTRIDER LED DISPLAY | Nov-88 | $7.15 |
| EC7671 | 3 | SC8108981 | HORACE THE CRICKET | Aug-90 | $5.65 |
| EC7673 | 4 | SC04309901 | LOW COST 3 DIGIT COUNTER | Jun-90 | $7.65 |
| EC7688 | 11 | SC9109P1 | LED DIGITAL ECHO | Aug-91 | $8.75 |
| EC7720 | 23 | SC01301952 | SA DRILL SPEED CONTROLLER | Sep-92 | $4.45 |
| EC7739 | 3 | SC07201941 | STEP MOTOR CONTROLLER | Jan-94 | $15.75 |
| EC7769 | 4 | SC14308941 | AUTO NICAD DISCHARGER | Oct-94 | $5.65 |
| EC7779 | 3 | SC02311941 | DALEY BUS CLOCK SHORT FORM | Dec-94 | $23.25 |
| AA0099 | 51 | SC01301952 | DIGITAL EFFECTS SWITCHING BOARD | Feb-95 | $1.00 |
| AA0098 | 1 | SC10304951 | DARKROOM TIMER | Apr-95 | $3.00 |
| EC7790 | 4 | SC11308951 | ELECTRIC FENCE CONTROLLER | Jul-95 | $9.25 |
| EC7792 | 3 | SC01207951 | GAIN CONTROL MIC PREAMP | Aug-95 | $5.65 |
| EC7794 | 5 | SC08310951 | VADER VOICE MKII | Sep-95 | $6.15 |

| CAT NO | QTY | BOARD NO | DESCRIPTION | ISSUE | PRICE |
|---|---|---|---|---|---|
| EC7802 | 9 | SC01309951 | 5 BAND EQUALISER | Dec-95 | $11.25 |
| EC7808 | 1 | SC05319951 | ENGINE IMMOBILISER | Dec-95 | $4.45 |
| EC7826 | 1 | SC02306963 | VIDEO AUDIO TX/RX | Dec-96 | $6.15 |
| EC7831 | 1 | SC03312962 | SMEC ALARM PANEL | Jan-97 | $14.15 |
| EC7833 | 1 | SC04103971 | CONTINUITY TESTER | Mar-97 | $5.65 |
| EC7836 | 8 | SC02303971 | MTSC TOUCH CONVERTER | May-97 | $8.35 |
| EC7838 | 11 | SC02305972 | COLOUR PATTERN GENERATOR | Nov-91 | $19.75 |
| EC7840 | 1 | SC04106971 | SIGNAL TRACER | Jun-97 | $5.65 |
| EC7844 | 1 | SC09107971 | RAIL POINTS CONTROLLER | Jul-97 | $6.70 |
| EC7848 | 2 | SC04310971 | 5 DIGIT DIGITAL TACHO | Oct-97 | $20.95 |
| EC7850 | 4 | SC10311971 | 10A MOTOR SPEED CONTROLLER | Nov-97 | $12.85 |
| EC7851 | 3 | SC05311971 | SPEED ALARM FOR CARS | Dec-99 | $15.45 |
| EC7852 | 3 | SC01011971 | STEP MOTOR PSU | Dec-97 | $3.90 |
| EC7853 | 6 | SC05311973 | SPEED ALARM FOR CARS | Jun-90 | $2.75 |
| EC7857 | 4 | SC05311972 | SPEED ALARM FOR CARS | Jun-90 | $3.65 |
| EC7858 | 4 | SC01112971 | 12V LIGHT SHOW BRD 1 | Jan-98 | $14.00 |
| EC7859 | 2 | SC01112972 | 12V LIGHT SHOW BRD 2 | Jan-98 | $4.45 |
| EC7861 | 4 | SC02302981 | GUITAR SUSTAINER | Mar-98 | $3.90 |
| EC7862 | 2 | SC04405981 | METAL DETECTOR | May-98 | $2.75 |
| EC7863 | 50 | SC04104981 | 3 LED LOGIC PROBE | May-98 | $1.75 |
| EC7865 | 5 | SC09105981 | RECIEVER DECODER | May-98 | $8.35 |
| EC7866 | 3 | SC09102981 | COMMAND STATION | Jan-98 | $10.15 |
| EC7867 | 112 | SC09103981 | STEP MOTOR CONTROLLER | Jun-98 | $8.35 |
| EC7890 | 20 | SC05308981 | GEAR SHIFT INDICATOR | Sep-98 | $10.65 |
| EC7882 | 49 | SC01307981 | WAA WAA EFFECTS PEDAL | Sep-98 | $7.25 |
| EC7888 | 102 | SC04112981 | THERMOCOUPLE ADAPTER | Dec-98 | $4.00 |
| EC7889 | 1 | SC05101991 | LED MINI KIT | Jan-99 | $5.85 |
| EC7894 | 3 | SC04101992 | CAPACITANCE METER | Feb-99 | $3.05 |
| EC7897 | 83 | SC01303991 | AUDIO COMPRESSOR KIT | Feb-99 | $6.00 |
| EC7911 | 1 | SC07406991 | REMOTE MODEM CONTROL | Aug-99 | $13.25 |
| EC7912 | 1 | SC04108991 | PC/VIDEO MONITOR CHECKER | Aug-99 | $12.75 |
| EC7914 | 1 | SC01109991 | TURN YOUR CAR INTO A VOLVO | Aug-99 | $7.00 |
| EC7915 | 1 | SC04109991 | ELECTRO CAP METER KIT | Sep-99 | $11.75 |
| EC7917 | 1 | PCB98452 | PCB VIDEO ENCLENCHER | Oct-99 | $9.00 |
| EC7925 | 51 | SC04101001 | A/V TEST GENERATOR | 01/00 | $9.50 |
| EC7927 | 1 | SC01101001 | SPRING REVERB | 01/00 | $11.00 |
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Ref Silicon Chip April 02
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Ref Silicon Chip March 02
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## Ricoh's "super combination" drive offers DVD+RW+R, CD/RW capabilities

Ricoh has launched what they claim is the most universally compatible disk drive in Australia. The latest in DVD and CD technology, the MP5125A is a "super combination" drive with DVD+RW and CD/RW and offering DVD+R capabilities. The MP5125A writes to DVD+R media at a 2.4x speed (equivalent to a 22x CDR writing speed).

DVD+R has also improved compatibility with DVD-ROM and DVD players, including Play Station 2.

In addition, the DVD+R capabilities will allow users to add data files to a multisession disk, whereas DVD-R can only use "write once" media. Consequently, the ability to "write many" makes the MP5125A much more adaptable and better value.

Ricoh says that the high speed DVD formatting time of under two minutes and the fast writing/recording capabilities of the MP5125A will also make it popular with users.

It also offers "direct to DVD" function which, with appropriate computer hardware, will enable direct recording of video from VCR and digital video camcorders. The bundled software will also support a variety of applications.

Recommended retail price of the MP512A drive is $1,099.00 (inc GST). Ricoh drives and compatible media are available from specialists nationally.

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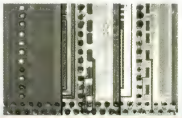
## FFT single-frequency imaging analysis

Sonoscan's new Virtual Sample Mode, a multiple-frequency echo of acoustic micro imaging using FFT (Fast Fourier Transform) filtering, is said to give engineers unprecedented views of a structure's internal features.

A range of frequencies around 230MHz is pulsed into the sample by a transducer. Reflection from an interface alters frequency distribution but the return echo encompasses a similar range of frequencies.

The result is 20-30 or more single frequency images, each giving a slightly different view of the internal defect or feature.



**Contact:**
**Sonoscan, Inc**
2149 E Pratt Bvd, Elk Grove Village,
Il USA 60007
Ph: 0011 1 847 6400 x 240
**website/email: www.sonoscan.com**

## Tandy now online

Tandy has launched an online version of their "bricks and mortar" stores, showcasing the large range of electronics products available.

The site features extensive product detail, images and stock availability, along with a store locator and "best buys" and "new products" pages. There is also a powerful search engine and the site is e-commerce enabled.

For those new to online shopping, Tandy has put together a guide which takes you step-by-step through the registration and ordering processes.

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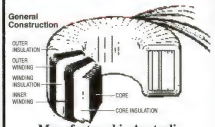


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## Clamp meter, idiot-proof DMM from Jaycar

A pair of recently-introduced digital meters from Jaycar Electronics are worth a second look!

First is a Clamp Meter which not only does the usual AC (200A) and DC (40A) current tests but also has standard multimeter-type leads for DC/AC voltage (600V max) and auto-ranging resistance, capacitance and frequency measurement plus duty cycle and diode testing.

It also features auto power-off, a data-hold function and one-touch zero.

Cat No QM1562 sells for $159 with pouch, leads and instructions.

Second is an ultra-large digit DMM which is not only auto ranging, it has shutters which automatically cover the unused input sockets so you can't make a mistake and cook your meter!

Along with the usual AC/DC voltage/current checks, it does capacitance, frequency, diode and continuity test. Cat QM1532 usually sells for $79 but is on special this month for $59.

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PO Box 6424, Silverwater NSW 1811
Ph: (02) 9741 8555 Fax: (02) 9741 8500
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## Turnkey 3-phase motor speed controller

Motorola, Inc's Semiconductor Products Sector has developed the MC3PHAC Motor Control Unit, a pre-programmed, variable speed, 3-phase AC motor control unit. The MC3PHAC provides a comprehensive motor control solution enabling sophisticated motor control without a high investment in development and software expertise. It is ideal for many industrial, automotive and home applications such as low-horsepower HVAC motors, home washing machines and dishwashers, commercial appliances, process controls, pumps and fans.

The CAPAC device is a high performance monolithic intelligent motor control unit designed specifically to meet the requirements for low-cost, variable speed, 3-phase AC motor control systems. The device is adaptable and configurable to its environment. It also contains all of the active functions required to implement the control portion of an open loop, 3-phase AC motor.

**Contact:**
**Motorola Inc**
**website: www.motorola.com/semiconductors**

## LED solutions from Sunbrite Group

Lumex Inc, a major international player in the LED market, has formed a new division, the Sunbrite Group, whose charger is meeting the needs of high-power illumination applications using LED solutions.

These include signage, traffic control, automotive and off-road vehicle lighting and general lighting.

As well as state-of-the-art chip chemistries, the group will utilise Lumex's polyLEDs, patented multi-chip units with discrete chips in dome lenses, available in virtually any colour.

Sunbrite already has a very wide range of LED products to suit virtually any application.

**Contact:**
**Lumex Inc**
286 E Helen Rd, Palatine Il 60067 USA
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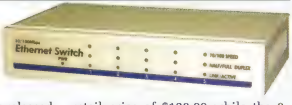
**website/email: www.subriteleds.com**

## New network hubs from DSE




Dick Smith Electronics has released two new 100Base-TX and 10Base-T switching hubs for small computer networks which are easy to set up and use.

There are two new models, one with five ports and the other eight. Both offer full and half-duplex capability and are suitable for most operating systems including Windows, Macintosh, Linux, OS2 and Unix.

The 5-port hub has a recommended retail price of $128.00 while the 8-port unit is $178.00.

Both are available from all Dick Smith Electronics stores, PowerHouse stores, mail order (Ph 1300 366 644) or via the web. SC

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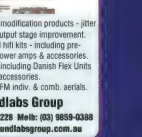

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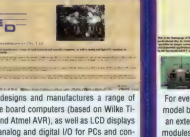

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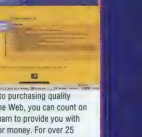

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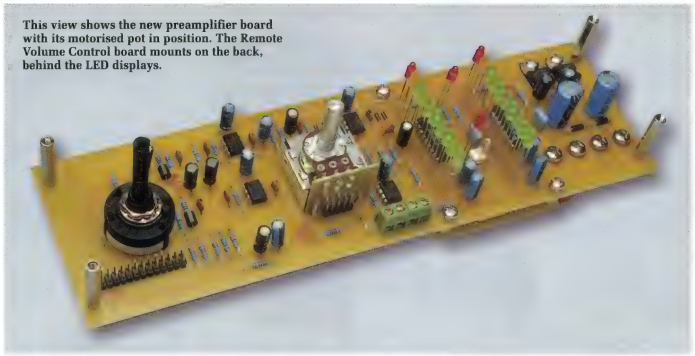


This view shows the new preamplifier board with its motorised pot in position. The Remote Volume Control board mounts on the back, behind the LED displays.

# Remote Volume Control for the Ultra-LD 2 x 100W Stereo Amplifier

**Do you want remote volume control for your Ultra-LD 2 x 100W RMS Stereo Amplifier? The remote volume control described last month fits neatly into the chassis, along with a re-designed preamplifier PC board.**

By JOHN CLARKE & GREG SWAIN

THE ULTRA-LD STEREO Amplifier described in the November 2001 to February 2002 issues has proven very popular. It delivers superb audio performance but there was one thing that was lacking – infrared remote control.

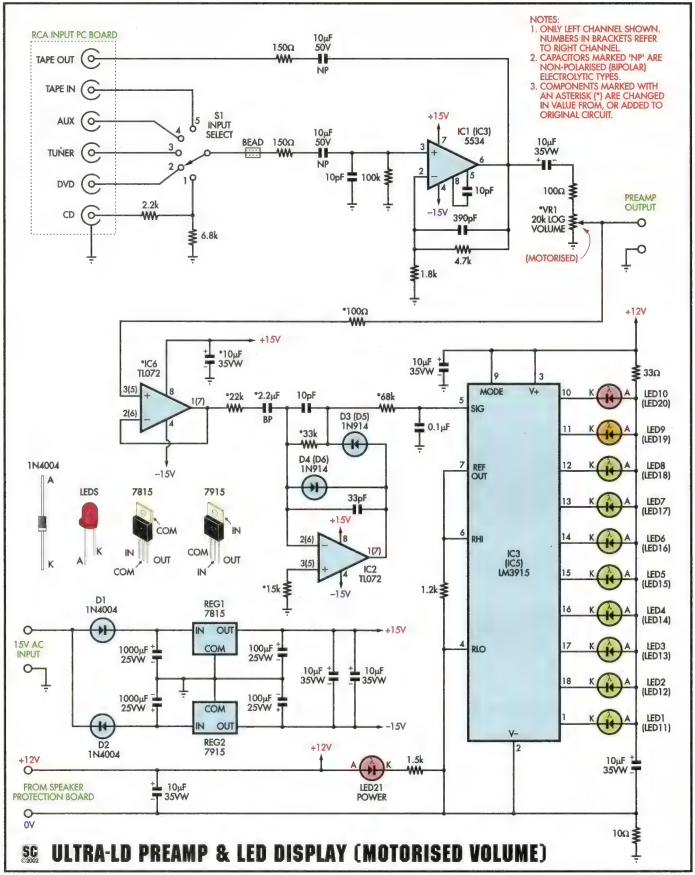
That's not usually important for such functions as power on/off switching and input selection but there's one thing you really do miss – remote volume control. As it stands, if you want to adjust the volume, you have to get out of your "comfy" chair, walk over to the amplifier, adjust the control and then walk back and sit down again. And that's just terrible – a real imposition for anyone.

Seriously though, remote volume control is a very convenient feature. Some CDs (or even individual tracks) can sound louder than others and a remote control allows you to quickly nudge the volume up or down at the press of a button.

Our approach here has been to fit the Remote Volume Control unit described last month to the Ultra-LD Stereo Amplifier. This unit not only provides remote volume control but also lets you to quickly mute the amplifier; eg, if the phone rings.

## Fitting it to the Ultra-LD

Actually, we had the Ultra-LD Stereo Amplifier very much in mind when we designed the Remote Volume Control. Unfortunately, there was just no way that we could fit the motorised pot into the chassis with the existing preamplifier. The pot's motor and gear-




# ULTRA-LD PREAMP & LED DISPLAY (MOTORISED VOLUME)

Fig.1: this is the new preamplifier and LED display circuit. It's virtually identical to the original circuit published in November 2001 but now includes buffer stage IC6 (TL072). This new stage isolates the audio signal on VR1's wiper from the precision rectifier stage based on IC2, thus allowing us to substantially reduce the resistor values in this part of the circuit to shunt leakage currents in humid weather.

## PARTS LIST

### ULTRA-LD PREAMP (REVISED)

1 PC board, code 01107021, 246 x 74mm
1 PC board, code 15106023, 26 x 23mm (to mount pot)
1 26-way DIL pin header
1 2-way polarised locking pin header & plug (2.54mm pitch)
2 2-way mini PC terminal blocks (Altronics P 2038) - 5mm pitch
1 2-pole 6-position switch (Altronics S 3022) (S1)
1 20kΩ motorised stereo log pot (VR1) – as used with Remote Volume Control
2 F29 ferrite beads
4 25mm-long M3 tapped spacers
4 double-ended male quick connects (Altronics H2261)

**Semiconductors**

2 NE5534AN op amps (IC1,IC2) (Altronics Z2792 – do not substitute NE5534N)
2 TL072 dual op amps (IC2, IC6)
2 LM3915 display driver (IC3,IC5)
1 7815 3-terminal regulator (REG1)
1 7915 3-terminal regulator (REG2)
2 1N4004 diodes (D1,D2)
4 1N914 diodes (D3-D6)
16 green thru-panel LEDs (LEDs 1-8, 11-18) (Altronics Z0711)
2 yellow thru-panel LEDs (LED9, LED19) (Altronics Z0713)
4 red thru-panel LEDs (LED10, LEDs20-22) (Altronics Z0710)

**Capacitors**

2 1000µF 25VW PC-mount electrolytics
2 100µF 25VW PC-mount electrolytics
10 10µF 35VW PC-mount electrolytics
4 10µF 50VW bipolar electrolytics
2 2.2µF 50VW bipolar electrolytics
2 0.1µF MKT polyester
2 390pF ceramic
2 33pF ceramic
6 10pF ceramic

**Resistors** (0.25W, 1%)

| | |
|---|---|
| 2 100kΩ | 2 1.8kΩ |
| 2 68kΩ | 1 1.5kΩ |
| 2 33kΩ | 2 1.2kΩ |
| 2 22kΩ | 4 150Ω |
| 2 15kΩ | 4 100Ω |
| 2 6.8kΩ | 2 33Ω |
| 2 4.7kΩ | 1 10Ω |
| 2 2.2kΩ | |

### SATELLITE BOARD

1 PC board code, 15106022, 46 x 23mm
1 8-way polarised locking pin header & plug (2.54mm pitch)
1 250mm-length of 8-way rainbow cable
1 infrared receiver/decoder (IRD1; transferred from Remote Volume Control board)
2 red thru-panel LEDs (LEDs1-2; transferred from Remote Volume Control board)
1 100µF 16VW PC electrolytic capacitor
1 2.2kΩ 0.25W 1% resistor (see text)

### MOUNTING HARDWARE

1 3-way polarised locking pin header & plug (2.54mm pitch) – to replace IRD1 on Remote Volume Control board
2 2-way polarised locking pin headers & plugs (2.54mm pitch) – to replace LEDs 1& 2 on Remote Volume Control board
4 10mm-long tapped Nylon spacers (to mount Remote Volume Control board)
12 M3 x 6mm screws
4 M3 nuts & washers
4 10mm-long tapped brass spacers
1 aluminium plate, 46 x 50mm (1mm thick) – see Fig.6

box take up a fair amount of space and it would have meant butchering the preamp board to get it all to fit.

In the end, there was nothing for it but to design a new Preamplifier & LED Display board to accommodate the motorised pot. And while we were at it, we decided to provide mounting holes for the Remote Volume Control PC board and to make a few circuit improvements.

Importantly, the new preamp board is a drop-in replacement for the old one. All the mounting holes, the LED displays and the controls are in exactly the same positions as before, so there are no extra holes to drill in the chassis.

As can be seen from the photos, the Remote Volume Control's PC board mounts on the back of the new preamp board, while the infrared receiver (IRD1) and the two LEDs (Acknowledge & Mute) have been transferred to a small satellite board. This satellite board connects back to the main board via a cable and matching pin headers.

As with the preamp board, you don't have to drill any extra holes to mount the satellite board. Instead, it's attached via a simple bracket to an existing mounting point for the lefthand power amplifier, so that IRD1 "peers" out through one of the vertical slots in the front panel. The Acknowledge and Mute LEDs sit back some way behind the slots but are still quite visible.

## Easier to build

The need to re-design the preamplifier board also gave us an opportunity to simplify the construction. In particular, the volume control pot is much easier to mount than before. The pot now mounts on its own PC board and this is soldered at right angles to a 5-way pin header on the preamp board.

In addition, we've now mounted the Speakers LED (LED22) on the preamp board, together with a pin header to accept the external wiring connections from the loudspeaker protector board. This does away with the old mounting method, which involved gluing the LED to a cable-tie mount attached to the front panel.

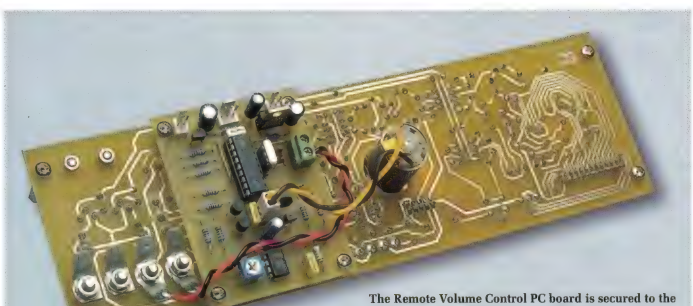
By the way, although the new preamp board has been designed to accommodate a motorised pot, you don't have to use a motorised pot if you don't want to. If you don't want remote volume control, just install a conventional pot instead.

Basically, this new preamplifier board supersedes the original design, whether you use a motorised pot or not. It differs from the earlier unit mainly in terms of layout, although there are also a few circuit changes which we'll detail below.

## Circuit details

Fig.1 shows the circuit for new preamplifier. It's virtually identical to the circuit published back in November 2001, so we won't repeat all the details. Instead, we'll concentrate mainly on the circuit changes.

As before, the audio signal is selected by switch S1 and fed to op amp IC1 which operates with a gain of 3.6.



**The Remote Volume Control PC board is secured to the back of the revised preamp board using 10mm Nylon spacers and machine screws and nuts. Note that IRD1 and the Mute & Acknowledge LEDs have been replaced with polarised pin headers.**

Its output appears at pin 6 and is fed to the volume control, to the Tape Out socket and to the LED display circuitry.

IC2 is the precision rectifier and this drives IC3 (the LED display driver) exactly as before. The big difference here is that we no longer drive the precision rectifier directly from the volume control. Instead, it is now driven via a unity-gain buffer stage based on IC6.

This buffer stage has a high input impedance and isolates the audio signal at the volume control from the precision rectifier. This in turn eliminates the need to use high value resistors in this section of the circuit.

To explain further, high-value resistors were previously necessary to prevent switching "spikes" generated by the precision rectifier from being fed back into the volume control. But although this was very effective, it could have one undesirable side effect – in humid weather, one or more LEDs in the bargraph displays could light for several minutes after switch on, due to moisture on the PC board.

The "cure" at the time was to connect 82kΩ resistors from the cathodes of D3 & D5 to ground, to shunt this leakage resistance. However, it wasn't a complete cure (as we subsequently discovered), at least not on the prototype – some LEDs could still light for a minute or so on very humid days.

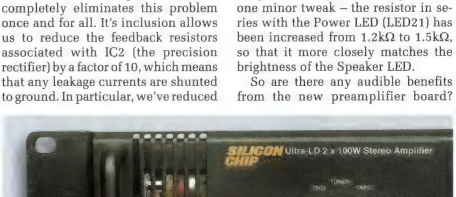
On the plus side, this hasn't been a problem with kit versions of the Ultra-LD Stereo Amplifier. The PC boards supplied by Altronics are solder-masked and so are unaffected by moisture. We could have fixed our prototype board by cleaning and spraying it with a protective lacquer but we never quite got around to it.

The new buffer stage based on IC6 completely eliminates this problem once and for all. It's inclusion allows us to reduce the feedback resistors associated with IC2 (the precision rectifier) by a factor of 10, which means that any leakage currents are shunted to ground. In particular, we've reduced the 220kΩ input resistor to 22kΩ, the 330kΩ feedback resistor to 33kΩ and the 680kΩ input resistor to IC3 to 68kΩ.

At the same time, the .01µF capacitor on pin 5 (SIG) of IC3 has been increased to 0.1µF so that the time constant for the LED drive signal remains the same.

Apart from that, the circuit is exactly the same as before except for just one minor tweak – the resistor in series with the Power LED (LED21) has been increased from 1.2kΩ to 1.5kΩ, so that it more closely matches the brightness of the Speaker LED.

So are there any audible benefits from the new preamplifier board?




**A small satellite board now carries IRD1 and the Mute & Acknowledge LEDs. This sits vertically behind the slots at one end of the case and is attached to a bracket which is secured by one of the power amplifier mounting screws. Make sure that IRD1 (arrowed) lines up with one of the slots.**

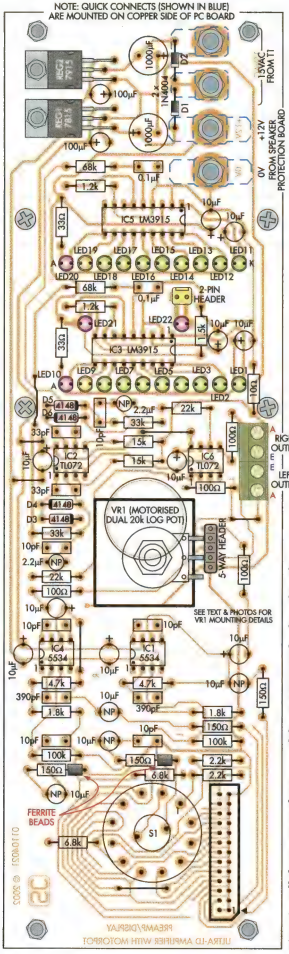



Fig.2: install the parts on the Preamplifier & LED Display board as shown here. The motorised pot sits flat against the board and is connected to the adjacent 5-way pin header via a small interface board – see Fig.3.

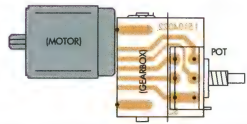



Fig.3: the motorised pot is mounted on a small interface board to make the connections easy.

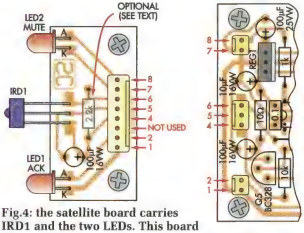



Fig.4: the satellite board carries IRD1 and the two LEDs. This board connects to the main Remote Volume Control board via pin-headers and a 7-way ribbon cable. Note that pin 3 on the 8-way header is unused.

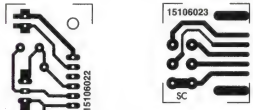
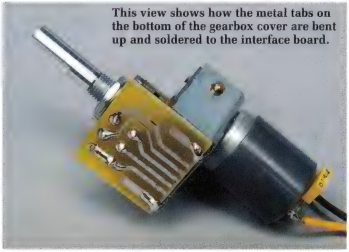
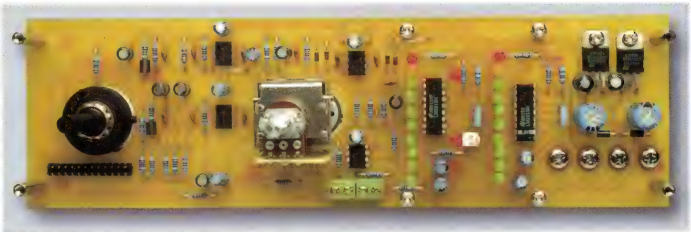



Fig.5: here are the full-size etching patterns for the satellite board and the interface board for the motorised pot.



This view shows how the metal tabs on the bottom of the gearbox cover are bent up and soldered to the interface board.



**This is the fully-assembled preamplifier board. The switch, volume control pot and mounting holes are all in the same positions as before, so there are no holes to drill. Make sure that all polarised parts are installed the right way around.**

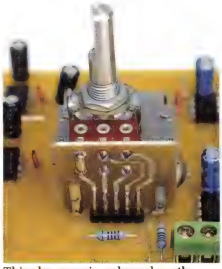
Nope – there are none! It's audio performance with regard to noise and distortion are almost exactly as before. If you already have an Ultra-LD Stereo Amplifier, there's no need to rush out and replace the preamplifier board with this new design – unless you want the remote volume control facility, that is.

## Construction

Fig.2 shows the parts layout on the revised Preamplifier & LED Display board. This board is coded 01107021 and has a large hole near the centre to accept the pot's motor. The pot itself pot is soldered to a small interface PC board coded 15106023 – see Fig.3.

Basically, it's just a matter of installing the parts on the preamp board as shown in Fig.2 and as set out in the December 2001 issue (be sure to refer to this article). The main differences from the earlier design are as follows:

- A 5-way pin header is installed to accept the pot connections;
- The new board includes buffer stage IC6 plus LED22 and its adjacent 2-pin header;
- Double-ended quick connect terminals are now used at the 0V and +12V positions. These terminals accept the supply connections from the Loudspeaker Protector board and also supply power to the new Remote Volume Control board.
- The Preamplifier and LED Display module is now attached to the front of the chassis using 25mm spacers (the



**This close-up view shows how the motorised pot is connected to the 5-way pin header. Note that the back of the gearbox cover sits flat against the PC board.**

**Table 2: Capacitor Codes**

| ❑ | Value | IEC Code | EIA Code |
|---|---|---|---|
| ❑ | 0.1µF | 100n | 104 |
| ❑ | 390pF | 390p | 390 |
| ❑ | 33pF | 33p | 33 |
| ❑ | 10pF | 10p | 10 |

**Table 1: Resistor Colour Codes**

| ❑ | No. | Value | 4-Band Code (1%) | 5-Band Code (1%) |
|---|---|---|---|---|
| ❑ | 2 | 100kΩ | brown black yellow brown | brown black black orange brown |
| ❑ | 2 | 68kΩ | blue grey orange brown | blue grey black red brown |
| ❑ | 2 | 33kΩ | orange orange orange brown | orange orange black red brown |
| ❑ | 2 | 22kΩ | red red orange brown | red red black red brown |
| ❑ | 2 | 15kΩ | brown green orange brown | brown green black red brown |
| ❑ | 2 | 6.8kΩ | blue grey red brown | blue grey black brown brown |
| ❑ | 2 | 4.7kΩ | yellow violet red brown | yellow violet black brown brown |
| ❑ | 2 | 2.2kΩ | red red red brown | red red black brown brown |
| ❑ | 2 | 1.8kΩ | brown grey red brown | brown grey black brown brown |
| ❑ | 1 | 1.5kΩ | brown green red brown | brown green black brown brown |
| ❑ | 2 | 1.2kΩ | brown red red brown | brown red black brown brown |
| ❑ | 4 | 150Ω | brown green brown brown | brown green black black brown |
| ❑ | 4 | 100Ω | brown black brown brown | brown black black black brown |
| ❑ | 2 | 33Ω | orange orange black brown | orange orange black gold brown |
| ❑ | 1 | 10Ω | brown black black brown | brown black black gold brown |

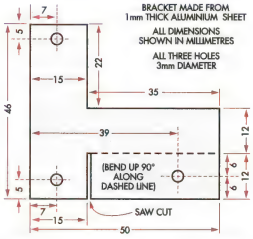



**Fig.6: here's how to make the metal bracket that's used to support the satellite PC board. It's made from light-gauge aluminium sheet.**

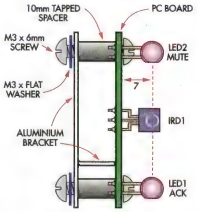



**Fig.7: the satellite board is attached to the bracket using 10mm tapped spacers & M3 x 6mm screws. Note that IRD1 and the two LEDs should be installed with their centres about 7mm above the board surface.**

previous module used 20mm spacers plus a spacer nut – ie, about 22mm overall).

As before, the LEDs must all be stood off the PC board so that they later protrude through their matching holes in the front panel when the PC board is mounted in the chassis. This is done by first inserting the LEDs into the PC board, then mounting the board to the front of the chassis on 25mm spacers and attaching the front panel.

The LEDs are then pushed through their matching front panel holes and their leads soldered.

Actually, it will probably be easier to quickly tack-solder the longer of the two leads for each LED, then remove the preamplifier board and complete the soldering. You will find that the LED leads are just long enough.

Make sure that the LEDs are all correctly oriented (the anode lead is the longer of the two) when installing them on the PC board.

Similarly, make sure that you install the rotary switch the right way around. Cut its shaft length to 26mm (use a small hacksaw) before installing it on the PC board with pin 1 located exactly as shown in Fig.2 (ie, at bottom right). Push the switch all the way down onto the board so that it is properly seated before soldering its pins.

Once the switch is in, rotate its shaft fully anticlockwise, then move its indexing collar one position anticlockwise so that it operates as a 5-position switch (see December 2001 issue).

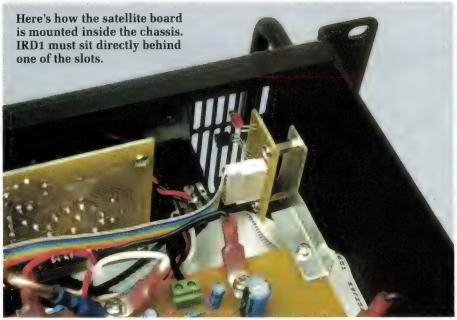
## Mounting the pot

Fig.3 shows how the motorised pot is soldered to its PC board (code 15106023). Make sure that it is properly seated before soldering its six pins.

Once these pins have been soldered, bend up the two metal tags on the bottom edge of the gearbox cover and solder them to the thick copper tracks at either end of the board (this provides extra rigidity). The motorised pot board can then be soldered to the matching 5-way header pins on the preamp board.

Make sure that the back of the pot's gearbox cover is resting flat against

**The view above shows the aluminium bracket with the two spacers attached while at right is the bracket with the satellite board fitted. Note that the Mute and Acknowledge LEDs sit back behind the front of IRD1.**



Here's how the satellite board is mounted inside the chassis. IRD1 must sit directly behind one of the slots.

the preamp board before soldering the tracks to the header pins. Note that you may have to bend the header pins slightly to ensure contact with the tracks on the pot board.

## Remote control boards

The main Remote Volume Control board is built exactly as described last month, except that IRD1, LED1 and LED2 are replaced by pin headers — see Fig.4. Be sure to install the pin headers the right way around, with their "backs" towards the edge of the board.

Fig.4 also shows how to build the satellite board. Install the parts exactly as shown, with the two LEDs aligned close to the edge of the PC board but with their centres about 7mm above the board surface – see Fig.7. You will have to bend their leads down by 90° about 3mm from their bodies before installing them.

IRD1 is installed at full lead length and its leads then bent by 90 (at both ends) so that it faces in the same direction as the LEDs (see photo). Adjust IRD1 for height so that it lines up with the LEDs but note that the front of its lens sits well forward of the two LEDs.

The 8-way pin header mounts with its back towards the edge of the board, as shown. **The 2.2kΩ resistor (shown dotted) pulls the output of IRD1 high and may be necessary for long cable distances** between the satellite board and the main board; eg, for distances over about 400mm. You can safely leave it out for cable distances less than this.

A length of 7-way rainbow cable is used to connect the two boards together. This is fitted with an 8-way header socket at one end and with matching 2-way and 3-way header sockets at the other end to plug into the main board. Note that pin 3 on the 8-way header is unused.

The Remote Volume Control should be tested before installing it into the Ultra-LD Stereo Amplifier. It's just a matter of connecting the pot motor and the satellite board, applying power and pressing a "volume" button on the remote to see if it works. Reverse the connections to the motor if the pot travels in the wrong direction.

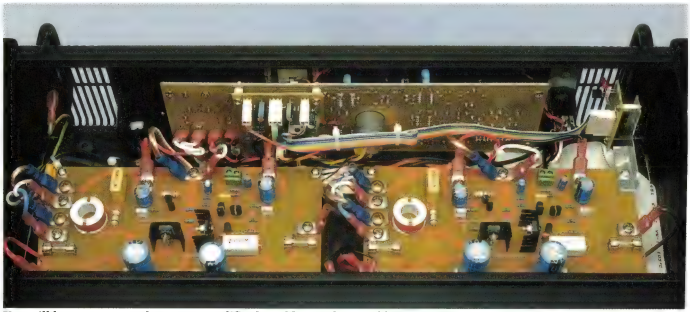
If the Acknowledge LED flashes when you press the button but there's no action from the motor, check the coding for the remote control unit (see last month's article).

Assuming it all works, the Remote Volume Control board can now be mounted on the rear of the preamplifier board using 10mm tapped nylon spacers and eight M3 x 6mm screws. Note that it may be necessary to first fit four of the screws with nuts (done all the way up), to provide the necessary clearance in the middle of the spacer.

Once the board is in place, plug the leads from the motor into the 2-pin header and install the power supply leads. The latter run from the screw terminal block and are soldered to the bottom lugs of the +12V and 0V quick connects on the preamp board.

## Installing the preamp board

You will have to remove the front panel and the power amplifier/heatsink assembly if you are retrofitting the new preamplifier into an existing Ultra-LD Stereo Amplifier. This is best done by first removing the side panels from the chassis. It's then basically a matter of removing the old board and slipping the new board into position



**You will have to remove the power amplifier board/heatsink assembly (see text) before installing the new preamp board in the chassis. There's plenty of room to accommodate the extra parts, including the pot motor.**

(although it's hardly a 5-minute job).

Don't forget to fit the shielded audio leads to the preamp board before installing it in the chassis. There's nothing more frustrating than reassembling everything and then discovering that you've forgotten to connect these leads (yes, it's happened to us). The same goes for the flat-ribbon input cable – be sure to plug it into it's header on the preamp board.

Provided that you've fitted the preamp board with 25mm spacers, you will find that the motorised pot is an exact fit (ie, the front of the pot sits against the chassis). It should be secured to the chassis using the supplied washer and mounting nut.

Note that you may have to slightly elongate the hole for the anti-rotation spigot, to suit the motorised pot. Don't try to bend the ant-rotation spigot on the pot – it will simply snap off.

The existing Speakers LED can either be left in place on the front panel or you can remove it and use the new one fitted to the preamp board. If you choose the latter, the leads from the Loudspeaker Protector have to be fitted with a 2-way header socket.

Remove the Speakers LED from the preamp board if you intend leaving the existing Speakers LED in place.

## Mounting the satellite board

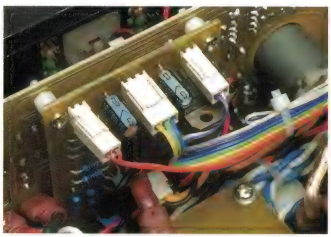
Fig.6 shows how to make the mounting bracket for the satellite PC board. It can be made from 0.8-1mm thick aluminium sheet (as used for the lids of project cases).

Cut out the bracket to the dimensions indicated before marking out and drilling the 3mm holes. That done, make a 12mm-long saw cut as shown (use a hacksaw with a fine blade), then bend up the bottom-right section along the dashed line.

The bracket can now be cleaned up using a light file to remove any burrs and by scrubbing it with steel wool.

Finally, the satellite board can be secured to the bracket on 10mm tapped spacers (see Fig.7) and installed in the amplifier. As shown in the photos, the foot of the bracket is secured using an existing mounting screw for the left-hand power amplifier.

Be sure to adjust IRD1 so that its lens is in line with one of the vertical slots in the front panel and don't forget to plug in the connecting cable. If the cable's too long, it can be tidied up by folding it back on itself and securing it with some cable ties.



**The connections from the satellite board to the main Remote Volume Control PC board are made via a 7-way flat ribbon cable and several pin headers.**

## Testing

Now comes the best bit but first make sure that the volume control is set to minimum (otherwise you could frighten the living daylights out of yourself). OK, fire up your favourite CD, sit back in your chair and smugly press the Volume Up button of the remote. The volume should smoothly increase and the Acknowledge LED should flash.

Finally, check that the Volume Down and Mute functions work as well and that the Mute LED lights correctly.

In practice, you will find that the Volume Up and Down buttons provide all the control you need. The Channel Up and Down buttons can be used to make very fine volume adjustments, if necessary. **SC**

# Tektronix TDS 2022

## 2-channel colour oscilloscope

***Did you swoon over the features of the Tektronix TDS 3014 and then blanch at the price? Well, Tektronix have now released a new range of LCD scopes, both monochrome and colour, at prices which are much more manageable.***

**We reviewed the TDS 3014** 4-channel 100MHz Digital Phosphor Oscilloscope back in July 2001. At that time it was a considerable breakthrough in bringing Tek's patented Digital Phosphor technology into a much cheaper package.

Even so, we have to admit that the price would still be too steep for many prospective purchasers. Over the past year, we have published screen grabs from the TDS 3014 to illustrate many of our articles and we regard it as a very fine instrument.

Fortunately, technology never stays still and many of the features of the TDS 3000 series (although not the Digital Phosphor technology) are now available in a range of smaller LCD scopes.

In fact, the size is similar if not identical to the revolutionary TDS 200 series released a few years ago. Smaller than a shoe box, this monochrome LCD instrument broke a lot of barriers and now the process continues.

There are seven models in the new range. The TDS1002 and TDS 1012 are 60MHz and 100MHz 2-channel instruments. Then there are the five colour models: TDS2002 60MHz 2-channel; TD2012 100MHz 2-channel; TDS 2012

# Tektronix TDS 2022 Oscilloscope

**Here's the long and the short of it (or should that be the short and the shorter?). These two photos show just how short in depth the TDS 2022 really is. Yet in that tiny box is packed a lot of 'scope!**

100MHz 4-channel; TDS 2022 200MHz 2-channel and TDS 2024 4-channel. All have the same input, timebase and trigger facilities except for the 200MHz models which have a maximum sampling rate of 2 Gigasamples/second (2Gs/s) instead of 1 Gigasamples/second.

We had the chance to sample the TDS 2022 for a few days and these are our reactions.

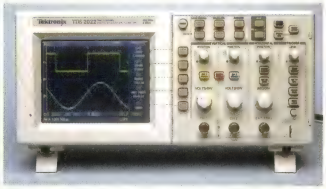
First, this is a small instrument. While its front panel and screen size are virtually the same as a typical 2 to 4-channel analog scope, it has relatively little depth. Its dimensions are 324mm wide, 152mm high and only 125mm deep, including the knobs and rear projections.

The LCD screen measures 115 x 88mm. The front panel has seven knobs and no less than 27 pushbuttons. On this model there are three BNC input sockets, one each for the channel inputs and one for external trigger (EXT TRIG) signal. The input sockets are not probe-sensing but probe division ratio can be set by push-button for the Ch1 or Ch2 menu to x1, x10, x100 and x1000. The power switch is on the top of the case, on the lefthand side.

Input sensitivity can be switched over a range from 2mV to 5V/div in the usual 1.2.5 sequence but you can also use the Channel input menu (CH1 or CH2) to select fine sensitivity adjustment for the Volts/Div controls. In this case, the sensitivity can be set with 3-digit resolution; eg, 4.88V.

The timebase can set for sweep speeds from 50 seconds/div to 2.5 nanoseconds/div, again in the usual 1.2.5 sequence. Notice that 50 seconds per division is extremely slow and at this speed it takes 500 seconds for the trace to sweep across the screen! If you are used to an analog scope, this low-cost digital scope with LCD screen has facilities which were undreamed of when the analog scope was king.

We've already mentioned on-screen menus and this is the great strength of the new digital scopes. In fact,



**This series of photos demonstrate some of the measurement capabilities of the Tek TDS1000 & TDS2000 series scopes. Photo 1 (left) shows the scope displaying a 5kHz sinewave and square wave together with associated measurements. Photo 2 (right) shows the FFT analysis (harmonics shown in frequency domain) of the 5kHz square wave.**

this scope does not come with a printed manual. Every function is supported by on-screen help so if you are uncertain about a measurement, just press the "Help" button and then scroll through the text.

Every button on the front panel is backed by on-screen menus, allowing you to make settings and select functions using the five buttons immediately to the right of the screen. Some of these functions require you to use one or more of the four small knobs on the front panel and the relevant knob will be indicated with a LED. For example, if you select cursors, the LEDs next to the two vertical position knobs light up to indicate that these are the ones to twiddle to move the cursors on screen. That's a nice touch.

## Trigger menu

The trigger menu on these new Tek scopes is quite impressive. You have a choice of Edge, Pulse or Video triggering. For pulse triggering you can set to trigger on a defined pulse width or when a pulse is greater, less than or not equal to the defined width. Video triggering is very impressive and you can sync on all fields, odd or even fields, all lines or select the line number (using the Trigger Level) control.

And as in all other Tek scopes, you have a great range of measurements, apart from those possible using vertical or horizontal cursors. You can make measurements on channel 1 or 2 from the following list: Frequency, Period, Mean, Pk-Pk, Cycle RMS, Min, Max, Rise Time, Fall Time, Positive Width and Negative Width.

Another impressive feature is the Math function. This allows you to add or subtract the channel 1 signal from channel 2 (or vice versa if you add the Invert function available from the channel input menu). More impressive is the incorporation of the Fast Fourier Transform (FFT) function so you can look at the signal in the frequency domain (using Hanning, Flat Top or Rectangular display).

In previous reviews of digital scopes, we have generally managed to have on-screen pictures to demonstrate some of the performance features but our sample scope had no output interface. There is one available which will allow screen grabs to be printed out to a variety of printers but there is no inbuilt floppy disk option. So the screen photos you see here are just that: photos (with all their limitations). And to be honest, they really don't do the screen complete justice.

You may also be wondering how we managed to get the screen pics with no probes connected? No, it's not trick photography. Notice the "Run/Stop" button top right of the TDS 2022 front panel? It freezes the current display until released. So we ran it, stopped it, unplugged it and snapped it!

OK. In the time we had this scope we were not able to check every feature but generally we were very impressed.

We do have a couple of minor quibbles. First, the feet to tilt the scope up to comfortably view the screen are just not big enough. The scope viewing angle is quite narrow both vertically and horizontally, so you do need to have the screen "square-on" as you look at it. Yes, you can tilt it up further using a book or two but the feet should be bigger. Easily fixed.

Second, the contrast controls (Contrast Increase, Decrease) seem to have more effect on the brightness than the contrast; at least they did in our sample. Surely this should be easily fixed as well.

Generally though, we think the new scopes will do very well. They are the easiest to use digital scopes we have come across and they are much more favourably priced than previous models.

## Where from, how much?

The prices are as follows: TDS1002 60MHz, $2140 plus GST; TDS1012 100MHz, $2770 plus GST; TDS2002 60MHz, $2770 plus GST; TDS2012 100MHz $3410 plus GST; TDS2014 100MHz $4285 plus GST; TDS2022 200MHz, $5125 plus GST and TDS2024 200MHz, $5995 plus GST. The TDS2CMA Comms Module, giving GPIB, RS232 and Centronics Ports, is $560 plus GST.

For further information on the new range of Tektronix TDS1000 and TDS2000 scopes, contact the Australian distributors, NewTek Sales Pty Ltd, 33 Paul Street North, North Ryde, NSW 2113. Phone (02) 9888 0100. SC

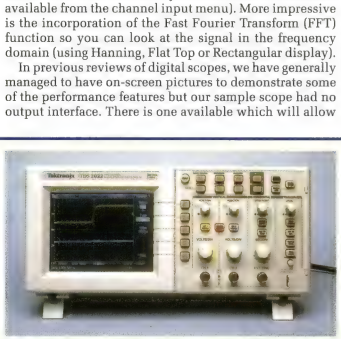


**Photo 3 (left) shows the leading edge of the 5kHz since wave and its rise time measurement of 132.5ns. Finally, photo 4 (right) shows the colour burst for a PAL video waveform**

# Creating your own rules for Tiny Personal Firewall

**LAST MONTH, we showed you how to provide good Internet security for your computer by installing a firewall. This month, we take a closer look at Tiny Personal Firewall and show you how to create your own packet filtering rules.**

**By GREG SWAIN**

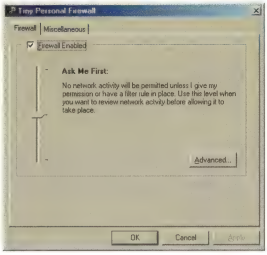



**Fig.1: Tiny Personal Firewall looks simple until you click the "Advanced" button.**

AS STATED LAST MONTH, you usually let Tiny Personal Firewall's wizard create its filter rules for you and then tidy them up afterwards if necessary. But what if you want to create your own rules from scratch?

There are several reasons why you might want to do this. For example, you might want to create some very specialised rules or you might want rules that apply only for certain time periods. Or you might just be plain pig-headed and want to do it all by yourself.

Another reason is that you might have an earlier version of TPF without Microsoft Networking and you have to manually create some specialised rules to filter a local network.

## TOP-DOWN RULE ORDER

As stated in last month's article, the Filter Rules defined in Tiny Personal Firewall operate in a "top-down" order. That means that the filter entries at the top of the table take precedence over entries lower down.

For example, let's say that you create a rule that allows access for machines with IP addresses from 192.168.0.1 to 192.168.0.20 but then have a rule further down that blocks access for 192.168.0.10 only. In that case, you'll find that the machine on 192.168.0.10 still has access through the firewall, since the top rule "clobbers" the rule further down.

The answer in this case is to move the "blocking" rule up the list, so that it is above the other rule. The blocking rule then blocks 192.168.0.10, with the following rule then allowing access for all the remaining machines.

Why would you want this type of setup? Well, for example, you might be on a small network and it might be more convenient to use a firewall to deny access for certain machines rather than rely on the use of passwords (which can be a real nuisance).

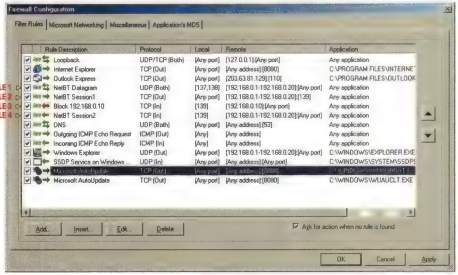



**Fig.2: the four rules indicated allow access by all machines on a local network with IP addresses ranging from 192.168.0.1 to 192.168.0.20. The exception is the machine on 192.168.0.10 which is blocked.**

## CREATING YOUR OWN RULES

Normally, of course, you'd use the Microsoft Networking dialog to set up

local networking rules but we'll show you how to do it manually here using a fairly simple example.

OK, let's say that we have a local network with IP addresses ranging from 192.168.0.1 to 192.168.0.20. What we'll do is create some simple rules that do the following:

(1) Allow the local (firewall) machine access to all machines in the designated IP range;

(2) Deny access by the machine on 192.168.0.10 to the local machine;

(3) Allow access by all other machines in the designated IP range; and

(4) Deny access to all other machines outside the designated address range.

To do this, we need to create four rules and these are shown in Fig.1 as NetBT Datagram, NetBT Session1, Block 192.168.0.10 and NetBT Session2 (you can call the rules anything you like).

Rule No.1 (NetBT Datagram) allows both incoming and outgoing UDP (User Datagram Protocol) packets (see also Fig.3). These are allowed in on ports 137 & 138 but only from machines within the designated IP address range so that machines on the local network can identify themselves.

Rule No.2 (Fig.4) allows outgoing TCP packets to connect to port 139 on all machines within the designated IP address range. This allows the computer with the firewall to access shared resources on the local network.

Rule No.3 (Fig.5) blocks incoming TCP packets on port 139 from the computer on 192.168.0.10. As a result, this computer is blocked by the firewall and is unable to access shared resources on the local machine.

Finally, rule No.4 allows incoming TCP packets on port 139 for all machines in the designated IP range. However, because rule No.3 is above rule No.4, the machine on 192.168.0.10 will still be denied access.

If you know what you are doing, you can quickly create these rules from scratch by clicking the Add button and filling in the details. Alternatively, you can let the wizard create the basic rules for you and then edit them.

The main problem with the wizard is that it can generate a lot of unsorted rules. For example, it will generate separate entries for any UDP packets on ports 137 and 138, one for outgoing packets and another for the incoming packets. By editing one entry, these can easily be combined and the surplus entry deleted.

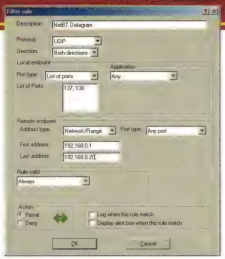



**Fig.3: Rule 1 for our network allows UDP data packets in both directions on local ports 137 & 138 and is necessary for name resolution.**

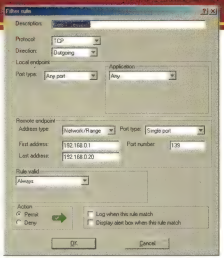



**Fig.4: this rule (Rule 2) allows all outgoing TCP data packets so that the machine can connect to any other machine in the designated IP range.**

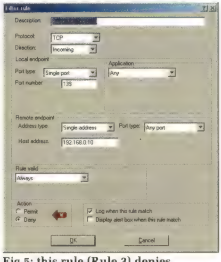



**Fig.5: this rule (Rule 3) denies incoming TCP data packets on port 139 from 192.168.0.20 and so prevents that machine from connecting. It also logs any connection attempts.**

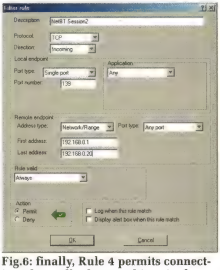



**Fig.6: finally, Rule 4 permits connections from all other machines in the specified IP address range by allowing incoming TCP connections on port 139.**

Be careful when creating filter rules – if you don't know what you're doing, it's all too easy to leave a gaping hole in your firewall! For example, if you are on a local network, be sure to create rules that accept connections to ports 137-139 (the NetBIOS ports) from trusted network IPs only. If you are not on a network, you should deny all connections to these ports.

Another thing to remember is that the rules set up under Microsoft Networking override any Filter Rules that you may create. This means, for example, that it's futile creating a rule to block a certain IP address (as in Fig.5) if it has already been granted access under Microsoft Networking.

Once you've created all your rules, it's a good idea to clear the box next to "Ask for action when no rule is found". That way, you won't be pestered by alerts popping up when ever unknown data packets are encountered.

## LOGGING

Finally, TPF can log information for each individual filter rule. This can be handy when tracking down intrusion attempts or for troubleshooting (eg, if the firewall is denying something that you want to let through).

If you want more information on configuring Tiny Personal Firewall, point your browser to:

**http://bookstore.free.fr/tinyfirewall/rules.html** **SC**

Pt. 1: By LEON WILLIAMS, VK2DOB

# Direct conversion receiver for the 7MHz amateur band

**Whether you're a beginner who just wants to "listen in" or an experienced radio amateur busting to build something, this 7-7.3MHz direct conversion radio receiver is just the shot. It offers good performance and features audible readout of the tuned frequency in Morse code. It's also very easy to build.**

IF YOU TAKE A WALK or a drive about your neighbourhood, chances are that you'll find some strange looking wire structures or overgrown TV antennas straddling some backyards. They probably belong to an amateur radio operator but while you may have heard about amateur radio, you may not know what really goes on inside their radio room or "shack".

You might not realise that they could be talking to another amateur just down the road or perhaps even on the other side of the world. They could be simply having a chat using single sideband (SSB), or conversing in Morse code (CW) or even seeing each other using slow-scan television (SSTV).

So, how can you find out what they're up to? Build this receiver, that's how – and maybe you'll be inspired to get your own amateur licence!

Of course, you don't have to be a beginner to build this receiver. If you have a licence already, you'll know that there's nothing more rewarding then assembling a radio receiver and hearing signals come through the headphones for the first time.

## Design features

While it may not have all the bells and whistles of expensive commercial radios, this receiver performs extremely well and is certainly better than a lot of simple designs that have

appeared over the years. Not only that, it even has its own frequency counter run by a PIC microcontroller!

A few decades ago, a receiver like this would have sported a metal tuning capacitor "gang" with a matching reduction drive and front-panel tuning dial, so that you could tell what frequency you were on. Unfortunately, metal tuning gangs are now almost extinct and good reduction drives are very expensive. In this design, they are replaced by a BB212 dual variable-capacitance diode and a PIC16F84 microcontroller.

The BB212 replaces the tuning gang and looks like a normal plastic transistor. It actually contains two variable capacitance (varicap) diodes joined at their cathodes and we can obtain a wide shift in capacitance by varying the voltage at the junction. In this receiver, the Main and Fine tune potentiometers provide the variable voltage.

## Morse frequency readout

The PIC microcontroller replaces the front-panel dial by accurately measuring the frequency of the local oscillator and injecting this as Morse code into the audio stages. To find the frequency that you are on, you simply press the FREQ button on the front of the receiver and hear the frequency announced (in Morse) in your headphones.

Although a little unusual, this technique is low in cost and requires a minimum of components to provide an accurate frequency "readout". In addition, it avoids the need for a big front panel and by using single PC board construction for the circuitry, we can fit the receiver into a small and inexpensive plastic case.

The receiver runs off a regulated DC supply of 11-15V and uses readily available parts. And that's not easy these days, as components for radio building are getting harder and harder to find.

## Tuning range

The prototype receiver has been built for the 40-metre band (7.00MHz to 7.30MHz) but could be adapted to another narrow band of frequencies anywhere between say 1MHz and 15MHz. This would involve changing the local oscillator tuning components and bandpass filter values for the new frequency. Note, however, that we haven't done any work along these lines.

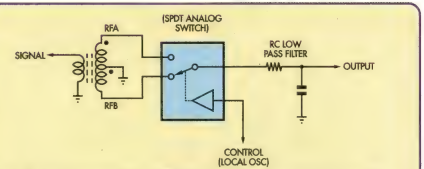



**Fig.1: the basic scheme for a switching mixer. The transformer provides two outputs 180° out of phase (RFA and RFB) to the inputs of a double-throw switch. As the control pin (Local Osc) alternates between high and low, the switches open and close and each leg of the transformer is connected in turn to the low-pass filter and the output.**

## Direct Conversion

The receiver uses the Direct Conversion (DC) approach. This is different to the normal receivers you have, such as in your clock radio, TV or car radio. They will almost certainly use what is called a "superheterodyne" (superhet) receiver. A superhet converts the signal from the antenna down to an intermediate frequency (IF), amplifies it and then demodulates it (ie, converts it to audio) using a second mixer.

By contrast, a DC receiver simplifies this by converting the input RF signal directly down to audio, in the first and only mixer stage.

In greater detail, the mixer in a DC receiver accepts signals from the antenna and a signal from a local oscillator and produces the sum and difference of the two frequencies at its output. Of course, there's no such thing as a perfect mixer and so there will be other frequencies in the output but these will be the dominant ones.

For example, assume that a Morse code signal on 7.100MHz is present at the antenna port of the mixer and that the local oscillator is tuned above the signal frequency at 7.101MHz. The main frequencies at the mixer output will be the sum of 14.201MHz and the difference of 1kHz. The inaudible high-frequency signals are filtered out with a simple low-pass filter, leaving the 1kHz tone for us to hear.

An important thing to note here is that we could alternatively have set our local oscillator to 7.099MHz, which is below the signal frequency, and the resultant audio tone frequency would still be 1kHz.

Setting the local oscillator 2kHz away on either side of the signal frequency would result in a 2kHz audio tone and so on. The level of the audio tone is related to the amplitude of the antenna signal and is independent of the local oscillator level. Of course, the level of the local oscillator must be sufficient for proper mixer operation.

While we need to offset the local oscillator for CW reception, to receive SSB signals we need to tune the local oscillator so that its frequency is equal to the transmitter's suppressed carrier frequency. When we adjust the local oscillator accurately, the transmitter can be transmitting either the lower or upper sideband and we will still demodulate the audio correctly.

In practice, tuning an SSB signal does not have to be this precise; we can adjust the local oscillator frequency a little either way and the audio will still be recognisable.

Things are different if we want to receive an AM signal, however. Here the transmitted signal is sent with a full carrier as well as both sidebands.

### MAIN FEATURES

- Suitable for use with SSB and Morse code signals.
- Frequency range: 7.0-7.3MHz (can be modified to cover any narrow band of frequencies within the range 1-15MHz).
- Morse code frequency readout.
- Power supply: 12V DC.
- Easy-to-build single board construction.

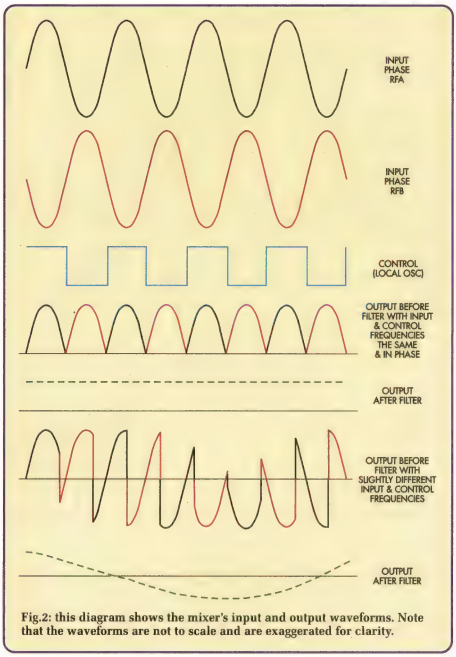



**Fig.2: this diagram shows the mixer's input and output waveforms. Note that the waveforms are not to scale and are exaggerated for clarity.**

To demodulate this type of signal correctly, the local oscillator must be at exactly the same frequency and in phase with the transmitter carrier. If we don't do this, the audio will sound modulated and will be hard to understand.

It's difficult to successfully demodulate AM with a DC receiver without additional complicated circuitry. However, it's not really important for amateur use because the bulk of stations use CW or SSB and only a very small number of operators use AM.

## Limitations

While DC receivers sound ideal, they do have some potential limitations. First, because there is generally little if any gain at RF, the bulk of the signal gain must take place at audio frequencies. In most cases, over 100dB is needed – especially if you want to power a speaker from antenna signals of less than a microvolt.

Unfortunately, it is common for audio amplifiers operating at very high gains to end up with problems such as feedback, hum pick-up, noise and microphonics.

However, the main limitation with a DC receiver is that we receive both sidebands simultaneously. For example, let's assume that our local oscillator is set to 7.100MHz and we are listening to a CW station transmitting on 7.099MHz. The decoded signal will generate a 1kHz tone in our headphones. But if another station starts sending on 7.101MHz, this signal will also be decoded and generate a tone of 1kHz. Obviously, this situation makes reception of the first station quite difficult.

A superhet receiver on the other hand can employ a narrow RF filter that only passes the wanted sideband, substantially eliminating interference from adjacent stations.

So while a DC receiver may not be the ultimate, for straightforward amateur use they work extremely well considering the simplicity of the circuit and the low number of components used.

Indeed, for the amateur builder, a DC receiver does have some advantages when compared to a superhet. They don't require multiple mixers and oscillators and there are no complicated alignment procedures involving lots of RF and IF circuits. What's more, there's no need to purchase an expensive sideband filter.

In practice, instability and noise in high-gain audio stages for DC receivers can be overcome with careful design. Similarly, the simultaneous reception of both sidebands is not really a big problem. People who have built and used DC receivers always comment on the fact that their performance belies their simplicity and that the recovered audio has an unexpected "purity" about it.

This is probably due to the low number of tuned circuits used and the lack of multiple mixers and oscillators that contribute to signal degradation in a normal receiver.

## CMOS mixer

Another unusual feature of this design is the use of a CMOS (74HC4066) analog switch as the front-end mixer. These chips are usually used to switch DC or audio signals but they are also equally capable of switching RF signals.

Traditionally, to obtain strong mixer performance, diodes arranged in a ring configuration are used. However, diode mixers require quite a bit of power to get them to operate effectively and if not designed correctly, are likely to exhibit poor performance.

The 74HC4066 on the other hand is

cheap and does an excellent job as an RF mixer. It has a very large dynamic range, which means that it can handle signals ranging from tiny sub-microvolt levels to several volts.

But while a large range is obviously an advantage, the ability to receive small signals in the presence of much larger signals is even more important. And in this respect, the 74HC4066 excels.

A strong signal handling capability is especially critical with direct conversion receivers, because at night on the 40-metre band (where extremely strong international shortwave stations abound), simpler mixers are prone to overload and demodulation of unwanted AM signals.

The mixer used in this receiver is called a switching type and to better understand how it works, a simplified circuit is shown in Fig.1. In addition, Fig.2 shows the mixer's input and output waveforms. Note that the waveforms are not to scale and are exaggerated for clarity.

While it may not be obvious at first, the switch is equivalent to one half of the mixer in the main circuit (Fig.3). In practice, the double-throw switch is made from two CMOS analog gates with their outputs joined. Note that two of these switching circuits operate out of phase to provide differential signals – more on this later.

In Fig.1, the transformer is connected so that it provides two outputs 180° out of phase (RFA and RFB) to the inputs of the double-throw switch. As the control pin (Local Osc) alternates between high and low, the switch effectively moves from side to side and each leg of the transformer is connected in turn to a low-pass filter and the output.

If the control signal has the same frequency and phase as the input signal, the output resembles that produced from a full-wave diode rectifier. After low-pass filtering, the output cannot follow the RF waveform and the result is a steady DC voltage across the load. This is the "zero beat" condition.

If, however, the input frequency and the control frequency are slightly different, the control switching is not coincident with the zero crossings of the input signal and the waveform gets "chopped". The resultant output after low-pass filtering is a sinewave with a frequency equal to the difference between the control and signal frequencies.

## Parts List

1 PC board, code 06107021, 171 x 133mm
1 plastic instrument case, 200 x 160m x 70mm
12 PC board stakes
1 4MHz crystal (X1)
1 red binding post
1 black binding post
1 SO239 panel socket – square mount
1 3.5mm stereo PC mount phono socket (Jaycar PS-0133)
1 18-pin IC socket
4 small self-tapping screws
4 3mm screws and nuts
1 large knob
2 small knobs
1 red momentary pushbutton switch
1 black momentary pushbutton switch
3 5mm coil formers
3 6-pin coil bases
2 metal shielding cans
2 F16 ferrite slugs
1 large 2-hole ferrite balun former
1 470µH RF choke

**Semiconductors**
1 PIC 16F84-04P (IC1) (programmed with DCRX.HEX)
1 74HC00 quad NAND gate (IC2)
1 74HC4066 analog switch (IC3)
2 LM833 dual op amps (IC4,IC5)
1 LM386 power amplifier IC (IC6)
3 BC547 NPN transistors (Q1,Q3, Q7)
1 BC557 PNP transistor (Q6)
2 BC337 NPN transistors (Q4,Q5)
1 MPF102 FET (Q2)
6 1N4148 signal diodes (D1-D6)
1 1N4004 power diode (D7)
1 7808 8V regulator (REG2)
2 78L05 5V regulators (REG1, REG3)
1 BB212 dual varicap diode (VC1)

**Capacitors**
2 470µF 25VW PC electrolytic
1 470µF 16VW PC electrolytic
6 100µF 16VW PC electrolytic
3 10µF 16VW PC electrolytic
2 1µF 16VW PC electrolytic
17 0.1µF MKT polyester
1 .022µF MKT polyester
4 .01µF MKT polyester
1 .0047µF MKT polyester
5 .0033µF MKT polyester
1 .0015µF MKT polyester
2 470pF polystyrene
1 330pF polystyrene
2 220pF ceramic
1 33pF NPO ceramic
1 10pF NPO ceramic
1 5.6pF NPO ceramic
1 40pF trimmer capacitor (VC2)

**Resistors** (0.25W, 1%)

| | |
|---|---|
| 1 1MΩ | 3 3.3kΩ |
| 6 100kΩ | 2 2.2kΩ |
| 4 47kΩ | 2 1kΩ |
| 4 22kΩ | 1 560Ω |
| 4 20kΩ | 3 150Ω |
| 1 11kΩ | 6 100Ω |
| 5 10kΩ | 1 10Ω |
| 8 4.7kΩ | 2 4.7Ω 5% |

**Trimpots**
1 2kΩ horizontal trimpot (VR1)
1 5kΩ linear 24mm potentiometer (VR2)
1 500Ω linear 24mm potentiometer (VR3)
1 50kΩ horizontal trimpot (VR4)
1 10kΩ horizontal trimpot (VR5)
1 1kΩ linear 24mm potentiometer (VR6)

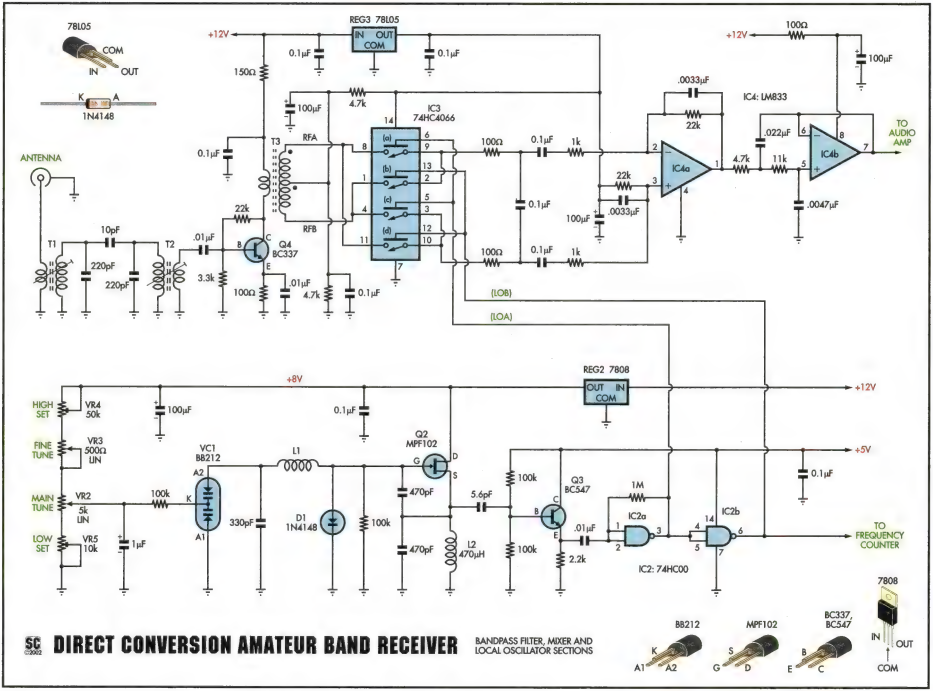
**Miscellaneous**
Light duty hookup wire, solder lug, tinned copper wire, 0.25mm enamelled copper wire, tinplate.

## Circuit description

The circuit for the receiver was a little too big for a single diagram, so we've split it into two (Figs.3 & 4). We'll look at the mixer and local oscillator sections first – see Fig.3.

As shown, signals from the antenna are coupled to an input bandpass filter (BPF), which comprises T1, T2, the 220pF resonating capacitors and the 10pF coupling capacitor. This filter is reasonably broad to allow 7MHz signals to pass easily but it attenuates unwanted out-of-band signals. The filtered signal is then coupled to a preamplifier stage based on transistor Q4.

It is not absolutely necessary to incorporate an RF preamp in a DC receiver. However, it has been included in this design to compensate for the losses in the BPF and the mixer and to




# DIRECT CONVERSION AMATEUR BAND RECEIVER

BANDPASS FILTER, MIXER AND LOCAL OSCILLATOR SECTIONS

**Fig.3 (left): the front-end circuitry of the DC receiver. The signal from the antenna is first fed to a bandpass filter and then to RF preamplifier stage Q4. Q4 in turn drives T3 which provides the two 180° out-of-phase signals to the mixer (IC3). FET Q2 is the local oscillator stage and this is tuned by the BB212 varicap diodes (VC1).**

improve the overall signal-to-noise ratio.

Q4's collector drives the primary winding of broadband transformer T3. This transformer's secondary windings are connected to provide the two 180° out-of-phase signals for the following mixer stage (IC3). Regulator REG3 provides a +5V supply for IC3 and also provides a 2.5V DC bias via two 4.7kΩ resistors at the centre tap of T3. This bias voltage is used to limit the signals fed to IC3 so that they are less than the supply rail voltages.

Note that the centre tap is grounded for AC signals by the 100µF and 0.1µF capacitors.

IC3a and IC3b form one half of the mixer, while IC3c and IC3d form the other half. The two lines labelled LOA and LOB are the local oscillator inputs – when one is high the other is low and vice versa. Switches IC3a and IC3c are turned on when LOA is high, while IC3b and IC3d turn on when LOB is high.

The inputs to the switches are driven by the secondary of transformer T3, while their outputs are joined together to form the double-throw switches referred to earlier. This results in the demodulated audio signals at pins 2 and 9 being 180° out of phase with those at pins 3 and 10.

This approach has the advantage of providing balanced (or differential) outputs and doubles the detected voltage compared to a circuit using just one set of gates. The balanced outputs are terminated by two 100Ω resistors and the RF is filtered out using a 0.1µF capacitor.

IC4a, one half of an LM833 low-noise op amp, is configured as a differential amplifier with a gain of 22. A mid-rail (approx.) reference voltage for the non-inverting input (pin 3) is obtained from the 5V output of REG3.

Following IC4a, the signal is fed to IC4b. This stage is configured as a 2.2kHz 2-pole Butterworth low-pass filter with unity gain. It's job is to filter out strong high audio frequencies early in the audio chain. The output from this stage appears on pin 7 and drives the audio amplifier input of Fig.4.

## Local oscillator

The local oscillator is a Colpitts type and is based around an MPF102 FET (Q2). The main frequency determining components are the two 470pF capacitors, the 330pF capacitor, inductor L1 and the BB212 tuning diodes (VC1). Tuning is performed by varying the voltage at the cathode pin of VC1.

Potentiometer VR2 is the main tuning control, while VR3 is the fine tuning control and adjusts the voltage by a smaller amount. To obtain the correct band coverage, two trimpots (VR4 and VR5) are adjusted to provide the required voltage for VR2 to span across.

The local oscillator is powered from an 8V regulator (REG2) to guard it from power supply variations. As a further precaution against frequency drift, L1 is wound on a former without a core. A ferrite core has a tendency to affect the inductance of the coil with changes in temperature.

The output of the local oscillator is coupled via a 5.6pF capacitor to emitter-follower stage Q3 which acts as a buffer. The signal on Q3's emitter is then amplified to logic levels by NAND gate IC2a. A 1MΩ feedback resistor biases IC2a in linear mode and forces it to operate as a high gain amplifier.

The output from IC2a is fed to IC2b which is configured as an inverter. As a result, the outputs of IC2a and IC2b operate 180° out of phase and they respectively provide the LOA and LOB signals for the mixer. The output from IC2b is also used to drive the frequency counter circuitry – see Fig.4.

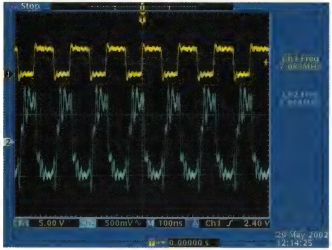
## Diode attenuator

An unusual feature of this receiver is the absence of a "normal" audio volume control pot (this would normally be connected between the audio preamp and the audio output stage). Instead, there are two points of variable electronic attenuation in the receiver, controlled simultaneously.

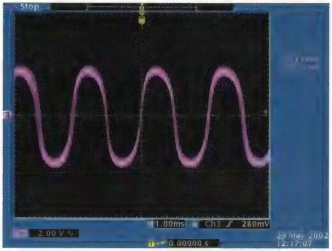
In this case, simple diode attenuators are used. A characteristic of a diode is that if a DC current is passed through it, its effective AC impedance is altered. Increasing the diode current from 0mA to 5mA or 10mA, for example, causes the impedance to decrease dramatically.

In this unit, two diodes are connected in series (at two separate points on the circuit) and the audio is fed to the junction of the two diodes – see Fig.4. A 10µF capacitor bypasses the supply and effectively places the diodes in parallel for AC signals. As the DC current in the diodes is increased, the impedance of the diodes decreases and more of the audio signal is shunted to ground.

D2 and D3 form the first attenuator, with the current through the diodes




**The two scope waveforms above show the receiver tuned to give an audible output. The yellow trace is the local oscillator measured at pin 3 or pin 6 of IC2. The blue trace is the input waveform measured at pin 4 or pin 8 of IC3. Note that there is a certain amount of crosstalk between the two waveforms, so that some of the local oscillator hash appears on the blue input waveform. The second screen shot shows the result, measured at pin 5 of IC6, an audible tone at 378Hz. Note that although the frequencies on the left screen have an apparent difference of 19kHz, this a measurement inaccuracy due to lack of resolution; the true difference is 378Hz.**




fed via a 150Ω current-limiting resistor. The 3.3kΩ series resistor connected between the output of IC4b and D2 and D3 is used to prevent the low impedance of the attenuator from loading the op amp's output.

This type of diode circuit is capable of attenuating signals by around 50dB. With no current in the diodes, there is essentially no attenuation of the signal. However, for this circuit to operate without distortion, the input signal level must be less than the diode turn-on voltage. This is the reason why the first attenuator is placed early in the audio chain.

It is also interesting to note that if the receiver had simply employed a standard volume control late in the audio chain, a very large antenna signal could have easily resulted in clipping in the audio preamp stages due to the high gains used. Controlling the signal level early in the audio chain is necessary to avoid distortion.

So why not use automatic gain control (AGC) as normally found in a commercial radio? Unfortunately, it is almost impossible to achieve successful results with AGC in a simple DC receiver. It was tried in the prototype but the usual problems of overshoot and distortion were encountered, so it was discarded.

## Amplifier stages

IC5a and IC5b are each one half of an LM833 low-noise op amp and provide a fixed gain block. IC5a is configured for a gain of around 8.5 and the .0015μF capacitor across the 47kΩ feedback resistor provides low-pass filtering. IC5b is configured similarly except that its gain is around 4.7, with a .0033μF capacitor across the 22kΩ feedback resistor to provide further low-pass filtering.

The large amount of low-pass filtering used in this receiver is necessary to separate the wanted signal from other nearby signals. A mid-rail bias voltage for both halves of IC5 is derived via two 4.7kΩ resistors and is filtered using a 100μF capacitor. Note that extensive capacitor bypassing has been employed throughout the circuit to eliminate audio instability. The values of the interstage coupling capacitors have also been selected to attenuate frequencies below 200Hz, to minimise susceptibility to hum.

The output from IC5b is fed through a 3.3kΩ resistor to the second diode attenuator stage, using D4 and D5. This works exactly the same as the first attenuator stage. Together, both attenuator stages provide a very large range of attenuation and by adjusting the Gain control (VR6), the enormous range of signal levels received by the antenna can be "evened" out.

Following the second diode attenuator, the audio signal is fed to an LM386 audio power amplifier stage (IC6) which has a gain of 20. The input (pin 3) also receives the Morse code from the frequency counter via a 100kΩ limiting resistor. The 10μF capacitor on pin 7 helps to reduce hum, while a Zobel network consisting of a 10Ω resistor and a 0.1μF capacitor is connected across the output to prevent instability at high frequencies.

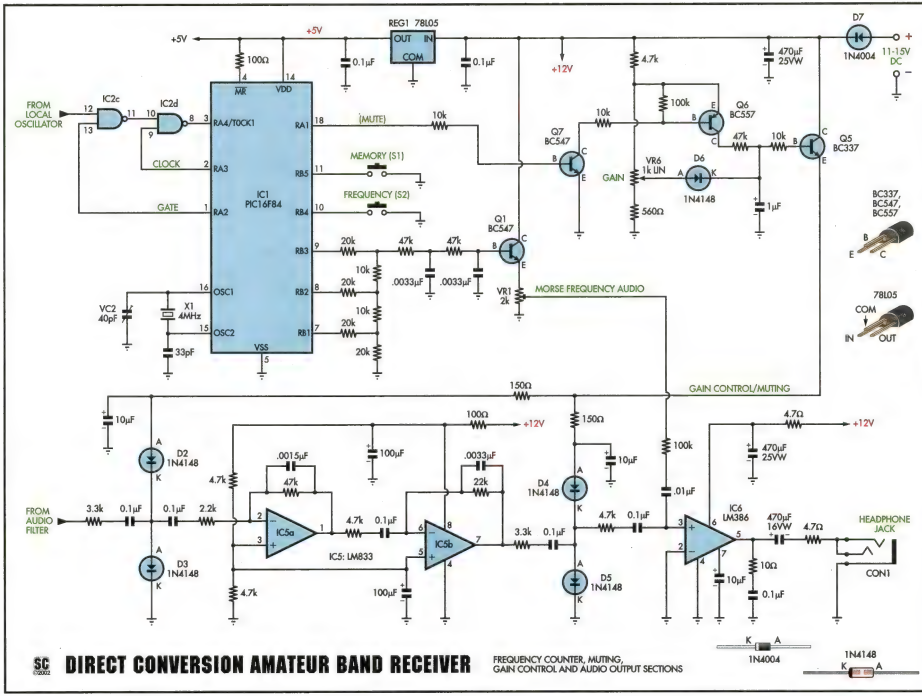
Power for IC6 is derived from the main +12V supply rail. This is applied to pin 6 via a 4.7Ω resistor which limits the current if the supply rail exceeds the maximum rating. The associated 470μF capacitor provides supply rail decoupling.

The output from IC6 appears at pin 5 and drives a stereo headphone socket via a 470μF capacitor and a 4.7Ω resistor. Note that the headphone socket has both active inputs wired in parallel, so that the audio will appear on both sides of stereo headphones.

## Headphone impedance

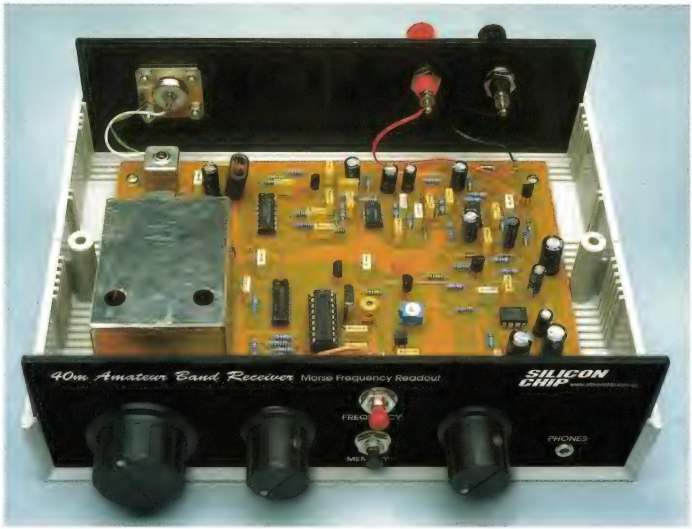
It is anticipated that lightweight headphones will be used, which normally have an impedance of around 32Ω. However, the 4.7Ω resistor connected in series with the output socket will maintain a reasonable load for

**Fig.4 (right): the frequency counter section of the circuit is based on PIC microcontroller IC1. This measures the frequency of the local oscillator and generates a Morse code signal which is injected (via Q1 & VR1) into audio amplifier stage IC6. Diodes D2 & D3 and D4 & D6 attenuate the audio signal according to the current supplied by Q5. This in turn depends on the setting of gain control VR6.**




**DIRECT CONVERSION AMATEUR BAND RECEIVER**

FREQUENCY COUNTER, MUTING, GAIN CONTROL AND AUDIO OUTPUT SECTIONS




**Most of the parts are mounted on a single PC board and there's very little external wiring, so the unit is very easy to build. The full constructional and alignment details will be published next month.**

IC6 if a loudspeaker or low-impedance headphones are used.

If a loudspeaker is to be used with the receiver, ensure that it is fitted with a stereo plug, because the sleeve connection of a mono plug will short one of the outputs to ground.

## Gain control

Transistor Q5 is connected as an emitter follower and supplies the variable gain control current to the attenuator diodes. The voltage on its base is controlled by VR6 (Gain) and is applied via D6 and a 10kΩ current limiting resistor.

The 4.7kΩ and 560Ω resistors in series with VR6 set the range for the gain control. When VR6's wiper is at the high end, maximum current will flow through the diodes and attenuate the signal to a point where even the strongest signals are almost inaudible. Conversely, moving the wiper to the ground side results in almost no diode current and therefore no attenuation of the audio signal.

## Signal muting

When the frequency counter is producing audio tones, the received audio is muted so that the Morse code can be heard unhindered. It works as follows.

The Mute line from the PIC chip (IC1) is normally low but is pulled high when Morse code is present. This turns on transistor Q7 which then turns on Q6 and Q5 to mute the received audio. At the same time, diode D6 becomes reverse biased and isolates the gain control (VR6).

The associated 1μF capacitor (on the cathode of D6) smooths the DC voltage from VR6. It also provides a degree of ramping for the mute voltage, to avoid thumps as the mute turns on and off.

## Frequency counter

IC1 (PIC16F84) forms the basis of the frequency counter. Although the addition of a microcontroller in a simple receiver may seem extravagant, the benefits of accurately knowing the tuned frequency far outweigh the extra cost and circuit complexity.

Power for IC1 is derived from REG1 which supplies +5V to pin 14, while pin 5 is connected to ground. The reset input (pin 4) is held permanently high via a 100Ω resistor and this simple system has proved to be sufficient to successfully reset the PIC each time the receiver is powered on.

The internal oscillator appears at pins 15 and 16 and a 4MHz crystal is used to supply accurate timing for the internal counters. The accuracy of the frequency measurement is dependent on the crystal oscillating at exactly 4MHz, so trimmer capacitor VC2 is included to allow fine adjustment of

the crystal frequency.

Pins 7, 8 & 9 of the PIC's Port B are allocated to a 3-bit digital-to-analog converter (DAC). This is used to synthesise an 800Hz sinewave to generate the Morse code audio signals. Following the DAC, a low-pass filter formed with 47kΩ resistors and .0033μF capacitors is used to round off the stepped waveform and make the waveform more sinusoidal. This sinewave is then buffered using emitter follower Q1, while trimpot VR1 adjusts the level injected into the audio amplifier.

Using an internal look-up table, the PIC software modifies the generated Morse signal to help limit clicks or thumps in the audio. First, the start and finish of each Morse segment has a ramped amplitude rather than being abruptly started and stopped. Secondly, when no Morse is being generated, the output voltage is set midway so that the sinewave swings positive and negative around a central point.

Two normally open pushbutton switches (S1 & S2) are connected to pins 10 & 11 of the PIC (Port B, bits 4 and 5). These pins have internal pull-ups and so are normally read as high. However, when a switch is pressed, the pin is pulled low and the software does a debounce check to test for a valid press. The FREQ switch (S2) is pressed to announce the current frequency of the local oscillator. The MEM switch (S1) allows you to store and retrieve a particular frequency (more on this later.)

The PIC is in sleep mode until interrupted by a switch press. It then processes the command and when finished goes to sleep again. While in sleep mode, the PIC consumes very little current but more importantly, the crystal oscillator is shut down. If this were not done, subharmonics of the 4MHz oscillator would interfere with the receiver in normal operation.

Pin 18 of Port A (RA1) is used to mute the received audio when the frequency is being announced. As mentioned earlier, it goes high at the start of the Morse code sequence and reverts to a low when the Morse code has finished.

## Reading the frequency

When a frequency read is called, IC1 counts the receiver's local oscillator cycles for exactly 100ms. For example if the local oscillator frequency is 7,123,456Hz, then 712,345 cycles will be counted, giving a resolution of 10Hz.

To count and store this value in binary form, a 20-bit register is required. However, the 16F84 only has a single 8-bit counter (Timer 0) that can be read directly. To make up this shortfall, we use an 8-bit software register for the most significant register and the 8-bit Timer 0 prescaler for the least significant register.

In operation, the signal from the local oscillator (LO) buffer appears at pin 12 of IC2c. The CLOCK line is held high for the duration of the read (100ms) – when the GATE line is high – to allow the LO pulses through to the PIC. After this period, the GATE line is taken low and the CLOCK is pulsed to allow the prescaler to be read.

Pin 3 of IC1 (RA4) is the input to the prescaler and is programmed to divide by 256. The output of the prescaler is then fed to the clock input of Timer 0. The overflow bit of Timer 0 is polled during the counting period and the software register is incremented each time an overflow is detected. This gives a 24-bit counter – more than we need but easy to work with.

Unfortunately, the prescaler is not readable directly by the software, so a trick is used to obtain its count. First, after the 100ms count period has elapsed, the Gate pin is taken low to inhibit counting of the local oscillator cycles. Now let's assume that at the end of counting, a value of 200 remains in the prescaler. If the Clock pin is now continuously pulsed, substituting for the local oscillator signal, the prescaler will overflow and increment Timer 0 after 55 pulses. So, if Timer 0 is monitored during this process for a change and the Clock pulses are counted, the value in the prescaler can be easily calculated. In this example, the count will equal 255 minus the Clock pulse count (55), or 200.

If you find this process a little hard to follow, you will find more detailed information in the 16F84 datasheets and the DCRX.ASM software listing.

Following the count period, the binary value is converted to 4-bit binary coded decimal (BCD) and finally announced in Morse code.

That's all we have space for this month. Next month, we'll describe the construction and give the full alignment details. **SC**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# VINTAGE RADIO

By RODNEY CHAMPNESS, VK3UG

# The Airzone 500 series receivers

**Airzone's 500 series radio receivers were typical of the 1930s era. This month, we take a look at the 505/515 models which were 5-valve superhets employing 455kHz IF stages but with no automatic volume control.**

During the early 1930s, Airzone (1931) Ltd produced a series of progressive receiver designs. The particular chassis featured here is a 500 (which has been modified to 500P standard), while the cabinet is a 555. And just to add to the confusion, the circuit diagram is for receiver models 505 and 515.

However, in those days, manufacturers often built a chassis which was fitted to different cabinets (table, mantel or console). The chassis had one number and the cabinet another, while yet another number was often given to the completed assembly.

## 1930s design philosophies

The early to mid-1930s was a time when superhet receiver design was really taking off. Before that, until about the end of the 1920s, consumers had to be content with tuned radio frequency (TRF) receivers which had reached the zenith of their design. But as good as many of these sets were, a new direction in design was needed to make radio receivers both economical to buy and easy to use.

Initially, superhets were even more cumbersome than TRF receivers, until tetrode and pentode valves became common. What's more, purpose-designed converter valves such as the 2A7 and later clones had not appeared commercially on the scene at the beginning of the 30s. To get around this problem, ingenious circuit designers developed the autodyne converter. This provided a local oscillator and achieved radio frequency (RF) amplification and conversion to the intermediate frequency (IF) all in the one pentode valve.

The IF amplifier design was well established early in the 30s and the generic design remained with us well into the solid state era. However, the design of the detector stage was in a state of flux at the time and the diode detector had yet to establish itself in the role it would come to dominate within a few years. Instead, during this period, many different types of detectors were used in radio receivers.

By contrast, audio amplifiers had also reached a reasonable degree of sophistication. Indeed, no further major design advances subsequently took place in domestic receivers while the valve remained king.

**The Airzone 500 came in a stylish cabinet and has just two controls: volume and tuning. The control settings are visible through "peep hole" escutcheons.**

## The Airzone 500/505/515

Fig.1 shows the circuit of the Airzone 505/515. The antenna/aerial circuit is quite standard for the era, with a 10kΩ potentiometer (R3) connected across the primary of the aerial coil. The potentiometer not only at-

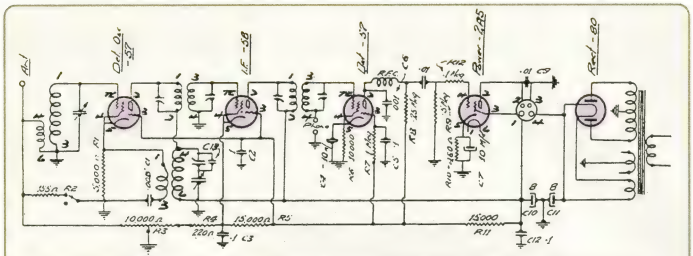


**Fig.1: the Airzone 505/515 series used a superheterodyne circuit with 455kHz IF stages but no AGC. R3 (at the antenna input) functioned as the volume control.**

tenuated the incoming signals but also increased the effective value of the 58 valve's cathode resistor (R4) from 220Ω up to a maximum of 10,220 ohms. Hence, R3 had the dual role of controlling the gain of the 58 and the amount of signal being fed to the 57 autodyne converter.

## Local/DX switch

A number of sets also included a "Local/DX" switch. This allowed a further reduction of receiver gain when strong stations were being received. On Fig.1, the switch is shown in series with R2 (155Ω) – ie, the 155Ω resistor was switched into circuit in the "Local" position, when strong signals were present. However, the receiver featured in this article does not have this facility.

Careful inspection of the circuit shows that the receiver has no volume control apart from R3. This meant that the set could still have had some audio output when R3 was set for maximum attenuation unless further measures were taken.

In fact, Airzone got around this problem rather nicely by including a voltage divider consisting of R11, R5, R4 and R3 across the high tension (HT) line. When R3 is at maximum attenuation (ie, the wiper is at the far lefthand end position), the voltage at the junction of R5 and R4 could be as high as 60V positive with respect to the chassis. As shown, the 58's cathode is attached to this junction, while its grid is at chassis potential, so in effect the bias can be up to -60V.

This is more than enough to completely cut off the 58 valve. And that meant that no signal could get through to the detector and so there was no audio output.

The converter is the common autodyne arrangement from the early 30s. Its operating conditions had to be carefully selected in order for it to work reliably. First, the cathode resistor is a rather high value compared to that used in a straight RF amplifier. Second, the padder is wired to the top of the oscillator tuned winding to ensure more reliable operation. This also keeps HT off the tuning gang, which is much safer for the user.

Note: having HT on the gang could also pose other problems. For example, if the gang plates shorted, there could be quite a "melt down". It would only be a matter of whether the oscillator coil burnt out before either the rectifier or power transformer succumbed!

## Autodyne problems

Early on, there was a problem with autodyne circuits getting enough feed-

**This view shows the rear of the cabinet, with the chassis in place. Loosening two screws underneath the cabinet allowed the chassis to slide out for servicing.**

# HRSA 20th Birthday Celebrations

**Recently the Historical Radio Society of Australia (HRSA), celebrated its 20th birthday over the weekend of the 20th and 21st of April 2002. Founded in 1982, it now has over 900 members.**

Vintage radio collecting in Australia had been going on for many years prior to the inaugural meeting of the HRSA on the 17th April, 1982. I commenced my collecting way back in the early 1970s, collecting military radio equipment from WWII. However, there were others before that who were collecting and restoring old radio equipment. Often, they were looked upon as rather odd people: "collecting old radios, you've got to be mad!"

In Alice Springs, Len Davenport had established a radio museum, called the "Magic Spark Radio Museum". Len believed that there was a need for an organisation to promote the preservation of our radio heritage. He spoke with Ray Kelly (in Melbourne) at length about the establishment of a national vintage radio club or society.

Ray organised a meeting at his home on April 17th, 1982. The idea was enthusiastically embraced and it was decided to form a national vintage radio society, to be called the Historical Radio Society of Australia. Starting with only 25 members, the society got under way immediately and their first newsletter was produced in July 1982, consisting of just a few pages of duplicated sheets.

From those very early days the society has expanded greatly to over 900, with members in every state and overseas. "Radio Waves" is now a quality magazine of 30-44 pages on all aspects of vintage radio and is published every three months.

Members can obtain advice on restoration, information on where to obtain bits and pieces, advertise for parts or sets that they are interested in, obtain circuits of most radios and in some cases identify that odd-ball set. Recently, the club established a "Valve Bank" and members can obtain most valves at reasonable prices from this source.

In the middle of 2001, the HRSA committee commenced their planning of the 20th birthday celebrations, to be held in the Brentwood Community Centre Hall, Mulgrave, Victoria.

Celebrations started on the Saturday at 9AM with a "Flea Market" – members buying and selling all sorts of vintage bits and pieces. At 12.30PM, the "Class Auction" got underway with over 100 registered bidders and quite a number more who came to see the valuable and not so valuable go under the hammer. Some pieces of rarer equipment brought prices well over the $1000 mark while other less sought-after items brought as low as $5.

## Radio displays

While the flea market and auction were on, a "Radio Display & Concourse" was also taking place. There were displays of early equipment from the Marconi spark era; 1920s, 30s & 40s receivers; coloured plastic/Bakelite radios; Australian battery portables; military radio equipment from WWII; posters; a display exclusively of the up-market Zenith (USA) portable receivers; transistor sets; and various other interesting items from our radio heritage.

The Bakelite cases of most radios were brown or occasionally cream. Some manufacturers did produce a variety of cabinet colours, either as mixes in the Bakelite or as a painted cover. These coloured sets are highly sought after, particularly blue ones which tend to sell for up to three times the price of a brown set. A number of these can be seen in one of the photographs.

Tony Maher, the owner of many of the battery portables on display, has been acutely aware that it is not possible or practical to operate bat-

**Valve radio receivers in coloured Bakelite cabinets are now highly sought after (especially blue).**

**A display of receivers from the 1920s. Finding parts for some old sets can be a real challenge.**

**These early radios all have one thing in common: attractive wooden cabinets. These have all been restored to "as-new" condition.**

tery portables from the batteries that were used in the past. Hence, he decided to design a DC-DC inverter to power these receivers.

He produced it as a kit and he has been besieged with requests for them. In this way, Tony is making our old valve portables useable as well as being display items. I applaud this as I believe that wherever possible our vintage radio equipment should be heard as well as seen.

The display was the best I've ever seen of this nature. The equipment was in immaculate condition and must have impressed the general public as well. The military equipment naturally didn't look anywhere near as "pretty" as the domestic radios, being more in keeping with its intended role. There were people around who could answer the questions of the visitors so that all knew more about our radio history than before they came to the display.

Those interested in finding out more can contact the HRSA at PO Box 2283, Mount Waverley, Victoria 3149. New Zealand enthusiasts can contact the New Zealand Vintage Radio Society (NZVRS) secretary at 2 Levy Rd, Glen Eden, Auckland, NZ. The NZVRS is older than the HRSA as it was established in 1979.

Both organisations have web sites. The HRSA web site is at **www.hrsa.asn.au**, while the NZVRS site is **www.nzvrs.pl.net**

**Early portable transistor radios are now very much collector's items. These have all been fully restored.**

back to sustain oscillation in the oscillator section. This problem was ultimately solved by the late Lay Cranch. He found that the primary of the first IF transformer impeded the feedback circuit.

In early circuits, the inductance acted as a choke and the capacitor was too small to allow sufficient feedback. This problem was solved by increasing the value of the capacitor and reducing the inductance.

## IF amplifier

The IF amplifier is quite a standard circuit. The main difference between it and later circuits is that it does not have automatic volume control (AVC/AGC). It relied instead on manual volume (gain) control, as provided by R3.

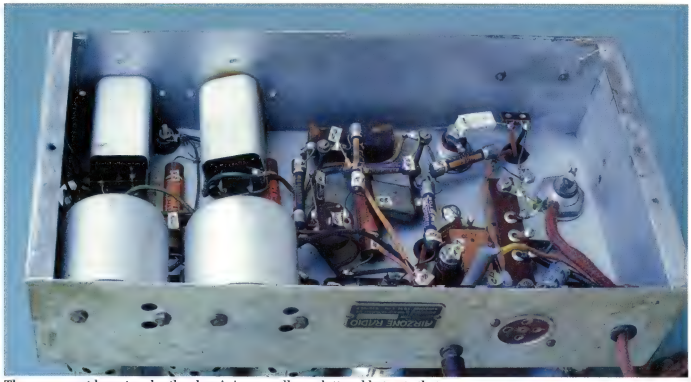
Most manufacturers at that time were using 175kHz IF (intermediate frequency) amplifiers, whereas Airzone used 455kHz IF amplifiers in this design. This meant lower gain than from 175kHz amplifiers but the image response was decidedly superior (which is why 455kHz later became the standard for domestic receivers).

The detector is an "anode bend" or plate detection type. This involves operating the 57 towards cut-off by using a higher than normal cathode resistor (R6). For best fidelity, the cathode should be bypassed only for RF (IF) frequencies but this reduces the overall gain. As a result, Airzone opted for higher gain but at the expense of increased distortion.

Electrolytic capacitor C4 should have had a 500pF mica capacitor across it to filter out any remaining IF signals. That's because electrolytic capacitors of that era had poor performance at both IF and RF frequencies after a short time in use. Filtering the IF energy at the plate of the 57 is standard practice with this design, to keep IF signals out of the audio output stage.

## Phono terminals

The 505 and 515 both have a pair of terminals to allow the use of a record player turntable to be connected to the receiver. The input is connected across the terminals marked "Phono" at the bottom of the second IF transformer secondary. However, noticeable distortion would be evident at the audio output with the circuit values used. In addition, the receiver's



**The component layout under the chassis is generally uncluttered but note that the coils sit over the top of three of the valve sockets. This makes it difficult to access components around these sockets for servicing. The IF adjustments are accessed through holes in the rear apron of the chassis.**

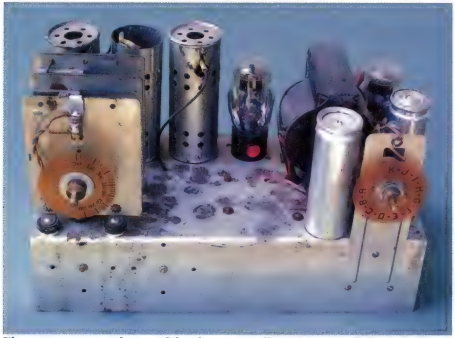
volume control would need to be set to minimum, to avoid radio stations coming in over the top of the record being played.

There is no volume control when playing records. For normal operation of the set, the phono terminals are shorted. The model 500 doesn't have this facility which is of doubtful value anyway.

## Audio output

The audio output stage is quite conventional. The electrodynamic speaker and speaker transformer are plugged into a socket which sensibly disconnects the HT voltage from the set proper when removed.

The power supply is conventional, with a transformer and an 80 rectifier. The heater winding for the majority of the receiver is 2.5V and it is centre-tapped to reduce the amount of hum in the audio output.



**The components on the top of the chassis are all easy to access. The two 8μF electrolytic capacitors near the power transformer were replaced but left in-situ on the chassis to keep the set looking as authentic as possible.**

## Restoring the 500

To remove the chassis from its cabinet, it is first necessary to remove the two knobs and the two bolts from underneath the cabinet. One interesting feature here is the fact that the bolts are located in slots. When loosened, this allows the chassis to be partly withdrawn so that valves may be replaced, as can be seen in one photograph.

At some stage during its history, this set had been converted from a 500 to a 500P. This meant that the 57 autodyne converter had been changed to a 2A7, the latter arranged in a much more reliable pentagrid converter circuit. The aerial and oscillator coils had also been replaced with much more modern units using adjustable slug cores.

The chassis was given a good clean up but the owner stopped short of repainting it as it was in good condition for its age.

Getting at the underside of the three

valve sockets holding the 58, the two 57s and other associated components below the coils and transformers is not easy. Why did manufacturers have to make life so difficult for service personnel when a more thoughtful layout would have made life so much easier? I've seen some radios and other equipment absolutely packed to the hilt with parts and yet due to thoughtful design layout are still easy to access. On the other hand, I have seen many chassis where access is difficult, like this Airzone.

The electrolytic capacitors were replaced but the 8µF chassis mount units were left in place to keep the set looking as authentic as possible. Several paper capacitors in critical positions, such as the grid capacitor to the 2A5, were also replaced. Some carbon resistors were out of tolerance and these were also replaced, as was R3 which was the worse for wear.

In sets of this age, it's not a bad idea to check that all the resistors are within tolerance (±20%). Some resistors can also become noisy and should be replaced, even if their value hasn't changed; eg, the plate resistor (R8) of the 57 detector.

The power cable was replaced with a modern 3-core fabric covered cable. It looks the part and has the vital earth wire which is sensible to have in sets of this age.

The receiver tuned circuits were then aligned without any difficulty. The dial is calibrated from 550 to 200 metres, which equates to 545kHz to 1500kHz (ie, the frequency range of the broadcast band at that time).

The IF adjustments are accessed through holes in the rear apron of the chassis. Two of the trimmers in the IF cans are at full HT voltage and should be adjusted using an insulated alignment tool. If you don't have the correct tool, you can cut down a large-diameter plastic knitting needle – just file a screwdriver blade on one of the pieces.

Once aligned correctly, the receiver had plenty of volume and reasonable sensitivity. The audio quality is typical of the era and type of detector used – in other words it isn't high fidelity but it's still quite listenable.

The controls are back to front to what we've become used to, with the tuning on the left and the volume on the right. The settings of both controls are visible through "peep hole" escutcheons. The volume control is easy to use but the tuning control is another matter. Due to the small size of the knob and the direct drive to the tuning capacitor, tuning is a finicky job at best.

## Restoring the cabinet

The cabinet was in reasonable condition, so not a lot of work was required here. First, paint stripper was used to remove all existing varnish and paint from the cabinet. The trims were then spray painted black, as was the inside of the cabinet (quite a lot of cabinets during that era were painted inside). Finally, the cabinet was finished off with satin/semi-gloss clear pre-catalysed lacquer spray.

The end result is shown in one of the photos – the set looks like new!

## Summary

Airzone was one of many manufacturers in the early 30s that experimented with new ideas, as demonstrated by the use of a 455kHz IF in this set. Converting the chassis to a 500P with a conventional purpose-designed frequency converter was a also good move.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The set itself certainly look the part, although it's a shame that looks took precedence over ease of tuning. The audio quality, although not high fidelity, is typical of the era and quite acceptable.

It is hard to assess what part of the market the set was aimed at, as it has some very good features as well as some cost-cutting measures. I suspect that it was intended as a middle-of-the-range receiver. It's a set that's well worth having in your collection, being typical of the 1930s era. SC


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## Nicad battery reconditioner wanted

I'm enquiring if SILICON CHIP has designed a kit to recondition nicad batteries. I'm looking for a unit that would automatically discharge/charge for about three cycles; preferably one that has the ability to condition batteries of different voltages.

These units are available commercially but the price is way past my budget. (B. B., via email).

● We have not published a battery reconditioner. However, we have published a number of nicad dischargers which could used in conjunction with a charger such as our universal design published in June and July 2001.

We really can't see the point of such reconditioners since if you discharge cells down to 1V each time and then fully charge, you should never need such a device.

## Measuring resonance with an oscillator

I am constructing a subwoofer enclosure as described in the January 1993 issue of "Electronics Australia". The article mentions checking the free-air resonance of the driver and then adjusting the top port length accordingly. We are unable to do this as per instructions. We were wondering if we need an amplifier between the oscillator and the speaker. (N. S., via email).

● We assume that you cannot measure the peak in the voltage as mentioned in the article. Putting an amplifier between the oscillator and speaker will not make it any easier. Can you measure any signal at all from the oscillator when it is connected directly to the woofer? If so, as you change the frequency, the voltage should change and you should get a peak at somewhere near 30Hz from the oscillator.

## MP3 Jukebox remote not working

My MP3 Jukebox is nearing completion, thanks to your articles. However I do have a problem. I can't get my AIFA Y2E remote control to work with your IR remote program.

Is there some obscure way of programming this thing that I don't know about? I bought it along with the kit, before I knew that the AV8E was recommended. (C. X., via email).

● Although we haven't tried the AIFA Y2E with IR Remote, we can't see any obvious reason why it wouldn't work. We assume you have tried the various 'Philips' brand settings (choose 'VCR' or 'AUX') as per the remote's setup instructions and the information published in the article (see page 31 of the September 2001 issue).

Of course, the other possibility is that there is a problem on the IR Remote & LCD display board. As a first step, make sure that the LCD portion of the hardware works OK with Hyperterminal (as detailed in the article). If that checks out, then double-check that the IR receiver module (IC3) is installed correctly.

Using your multimeter, verify that when the IR receiver module is plugged in, all three of its pins make reliable contact through the socket strip and onto the PC board tracks. Also, make sure that the IR receiver leads do not contact the LED leads when the assembly is bolted home.

## Insulation tester does not produce 1000V

I have just purchased your High Voltage Insulation Tester from May 1996 to use in checking insulation breakdown in condenser microphones. As breakdown in resistance in the capsules can cause noise problems, this unit would be a good way of checking the capsules.

My problem is that I can't see how your circuit can achieve up to 1000V as indicated on the circuit and in the text. I am only getting 93V DC on the 1000V range and this is all I would expect when using a transformer with a 1:7 turns ratio.

Am I missing something? (R. L., Chatswood, NSW).

● It is true that the transformer has a turns ratio of only 7:1 but the Mosfet is the real voltage generator and the voltage generated at its drain is according to the formula: e = L.di/dt.

The principle is exactly the same as in a car ignition coil. If you are only getting 93V, it suggests the FET is not turning off properly or the feedback is not correct. Use a scope to check the voltage you are getting at the drain of Q1.

By the way, how are you measuring 93V? Even with a 10MΩ multimeter,

## More gain for universal preamp

Having constructed the stereo preamp from the April 1994 issue, I find the gain is insufficient for my requirements. I'm trying to use it with my computer sound card to burn LPs to CD. However, the output is not sufficient to drive the soundcard's line input to a reasonable level.

It would appear that another 3 or 4dB would be required, judging from the levels showing up in my sound editing application. Can I just reduce the 390Ω resistors (R4) to provide more output or will the equalisation be upset?

On a completely different note, I've tried the DOS MP3/WAV player mentioned on page 5 of the February 2002 issue and I highly recommend it. As someone who uses DOS and WFW 3.11 for most applications it's great to see this kind of software. (J. H., via email).

● You can increase the gain by reducing the 390Ω feedback resistor. However we have not tried it and would not like to see it reduced below, say, 270Ω.

you will only be able to measure about 500V.

## Linear steps for photographic timer

I am interested in the photographic timer described in April 1995. Timers for enlargers need to be set in seconds, in 1s steps. 1/2s steps would be better but is not necessary for a simple timer. I guess this is a matter of changing the value of the resisters round the rotary switch. Could you provide the values of those, for 1s steps, please? (W. O., via email).

● As stated in the April 1995 article, the timing intervals increase in geometric progression, in order to give increases in exposure which are equivalent to half a stop.

The problem with just increasing in seconds is that you only get a range of 1-12 seconds with a 12-position switch instead of 1-45 seconds as in our design. However, if that's what you want, it is easy. Just connect 12 39kΩ resistors around the switch.

## Tremolo oscillator not operating

I have recently constructed the Tremolo kit described in the April 2001 issue of SILICON CHIP. I have tested the unit and found it to have the correct voltage between the pins of each IC as specified in the instructions but LEDs 2 and 3 do not light alternately. Instead, LED 3 stays on.

There is also no output from the unit when a guitar is plugged in, regardless of S2 being in or out. I have checked the PC board against the pattern and found no faults, resoldered and checked the continuity of all joints plus double checked the direction of all components and found nothing wrong. Could you please help? (L. M., Avalon, NSW).

● The oscillator does not appear to be operating, as indicated with only LED 3 staying on. Check that pin 3 of IC2a and pin 5 of IC2b are at half supply. This would be +6V with a supply rail of 12V. Make sure the correct components are connected to IC2a and IC2b. Check that the TL072 ICs are placed in the IC1 and IC2 positions. The TL071 goes in the IC3 position.

Check that switch S2 is off so the tremolo oscillator can run. Check that the depth and rate potentiometers are the correct value. The depth potentiometer is 10kΩ while the rate pot should be 100kΩ.

## Questions on JV-60 speaker kit

I refer to the JV-60 3-Way Speaker System featured in the August 1995 issue of SILICON CHIP. I am not an experienced speaker builder but I would like to have a go at making these cabinets and I have a few questions about it.

Is there any advantage in using much thicker MDF – say 25mm? I take it that if I use the thicker material I should adjust the external measurements to get the same internal dimensions. If I use Jarrah timber and not MDF (for example, for the sides and top), do I need to change anything to get the same performance characteristics?

Would another internal brace be of value? If so, where should it be located? How critical is placement of the Innerbond sound absorbent material? Should this be stuck to the top, both sides, rear, etc?

Finally, I believe the speaker enclosures would look better if the drivers were countersunk into the front panel. Is this recommended? (D. L., via email).

● Yes, you can use thicker material and adjust the outside dimensions to give the same internal volume. You can also use real timber but it will cost lots more than MDF. Additional braces on the longer panels can be worthwhile but remember to compensate for the volume they take up.

You can mount the speakers flush with the baffle and that can lead to a smoother frequency response – it's just more work. The placement of the Innerbond material is not critical.

## Grounding improves Theremin sound

I have just built the Theremin described in the August 2000 issue and all is well. I do have two questions though. I swapped the headphone jack for one that is big enough to accept a cord from my guitar amplifier. I noticed a distinct improvement in the sound output. My first thought was that it was the amplifier that just had better sound. I shut off the amplifier and the speaker that came with the kit still preformed well.

I unplugged the cord from the amplifier and the sound quality was not as good. Then I noticed that if I left the cord from my amplifier plugged into the Theremin but touched the bare metal of the other end of the cord, the sound improved again. Does this circuit need to be grounded in some way to give better performance? Because from an uneducated guess I'd say that's what I'm doing with the amplifier cord right?

With the volume plate I'm getting some variety in sound levels but not as much as I imagined I would be getting. I thought I would be getting a range of totally silent to loud and all levels in between. Is there an adjustment I'm missing? Fine tuning VR2 has helped a little but not as much as

## Problems with white LED torch

I recently purchased the Dick Smith kit for the 6-LED Torch described in May 2001. It did not work, unfortunately. I thought that I may have cooked the MAX1676 SMD even though I was very careful and used a heatsink to make sure that it did not get hot. I then purchased a second MAX1676 and again taking great care and using a heatsink, I soldered it to the U10-Max board. All connections to the MAX1676 check out. There are no open or short circuits.

I have even checked the MAX-1676 under a microscope and find no evidence of external damage or short circuits. I have also checked all other components on the board and can find no problems.

As this is the only "active" component on the board I feel that either I have a dud MAX1676, I have been careless or there is a problem in this circuit. There is continuity with the LED array. Using a standard alkaline 1.5V cell, I find that the output to the LED array sits at 1.4V. The DC-DC converter is obviously not working! Please help. (S. P., Townsville, Qld).

● Check that there are no shorts between adjacent pins. Also, the Schottky diode may be incorrectly oriented or short circuited.

Make sure that there is continuity through the inductor to the PC board. The insulation on the wire may not be clean enough for the solder to take without causing a dry joint.

I expected. (H. D., via email).

● You have raised an interesting point. The added grounding using the output lead will retune the Theremin and possibly produce a better sound. Alternatively, careful retuning of the Theremin should give the same improvement.

The Theremin also requires careful tuning of VR2 to obtain the correct volume adjustment. It should be possible to adjust it so that the volume can be completely shut off with your hand close to the plate.

Tuning should be done with the leads connected to the external amplifier if you intend to use it this way.

## Operating the Minivox at 9V

I bought the Minivox kit described in the September 1994 issue of SILICON CHIP from DSE. The kit works at 12V DC but can it run from a 9V battery? (O. S., via email).

● The circuit should work at 9V but you may need to increase the value of the 2.2kΩ resistor at pin 6 of IC1 to 3.3kΩ or 4.7kΩ for reliable operation.

## No bargraph in mixture meter

I have a query regarding the Digital Fuel Mixture Display kit described in the September & October 2000 issues. Everything works fine on this kit, except that it will not go into bar mode. I have tried the resistor across pin 7 and ground of the PIC but it still will not start up in bar mode. (volts & propane mode work fine) Is there a software problem? (A. M., via email).

● Try using a smaller value for R1. The internal pullup resistance on the RB1 pin may be more than the specification quoted in the data sheet and so the RB1 input is read as a high rather than a low when R1 is in place. A 1.5kΩ resistor or even 1kΩ should make the bargraph mode operate.

## Motor speed controller stalls grinder

We purchased a motor speed controller kit from Dick Smith Electronics to control the speed of a grinder (9A universal motor). When initially constructed, we achieved very good control of the grinder at low and high speeds with good torque at low speeds.

Recently though, the MOV blew up in the unit. We checked all the other components, replaced the MOV and it appeared to work OK. However when we use it with the grinder we find it now stalls under load, at any speed.

We have checked the unit on an oscilloscope with a resistive load (7.5A) and the output waveforms are as they should be. We don't seem to be able to find anything wrong with the operation It is achieving full output voltage to the load and will regulate PWM when current is increased.

When used on the grinder it takes considerable time to reach full speed and then consistently stalls once the grinder is loaded up, which would suggest the feedback circuit is not working correctly. Can you suggest a fix? (L. B., via email).

● The 4050 (IC2) will need replacing if the IGBT blew up. This driver determines the on-resistance of the IGBT when the gate is high. Also check the 10Ω gate resistor. You cannot measure the .033Ω resistor with a standard multimeter. It can be tested by applying a current through it (when out of circuit).

## Remote control train controller wanted

Now that remote control projects are everywhere, how about a remote control model train speed controller? (S. B., via email).

● We published a remote controlled train controller in the October & November 1999 issues and followed it up with a walkaround throttle version in December 1999. If you missed those issues, we can supply them for $7.70 each, including postage.

## Circuit for surround sound decoder

I am looking for a circuit for a "surround sound decoder" to add to my stereo TV which is about 8 years old. (P. L., via email).

● EA magazine published surround sound decoders in May 1995 and May 1999, the latter circuit with a digital delay. We can provide photostat copies of these articles for $8.80 each, including postage.

## Sunlight displays for speed alarm

I have completed the Speed Alarm from the November & December 1999 issues. It works well but as the unit must be mounted in a particular position, it is OK while driving in the evening and dull weather but no good in sunlight.

I have tried an opaque red window and a hood over the entire unit and hooded the display as well but it is not acceptable. Have I got a common

fault? Can the segment currents be elevated a little via the 150Ω resistors or would a green display be more appropriate? (F. D., via email).

● The speed alarm LED displays specified are not suitable for reading in direct sunlight. Suitable high brightness sunlight viewable displays are available (in red only) and can be used as a drop-in replacement for the standard displays. Agilent common anode HDSP-H151 are the ones to use. Their output is 16mcd (milli-candela) at 20mA compared to 1.3mcd at 20mA for standard displays.

The HDSP-H151 displays are available from Farnell, Cat No 264-313. Phone 1300 361 005.

## Rev limiter and gear shift indicator

I recently bought the Rev Limiter and Gear Shift Indicator (SILICON CHIP, April 1999) from Jaycar at Penrith. However, I just found out that I already have a Rev Limiter in my car and I was wondering if I could bypass the Rev Limiter and use it as a gear shift indicator only. (B. D., via email).

● If you already have a rev limiter then don't connect the Ignition Switcher board. Connect the input of the rev limit controller board to your distributor (points, reluctor etc), connect the +12V supply and that's all that's needed.

## Multi-Spark CDI on a VW

In the information pack enclosed with a Dick Smith Electronics kit for the High Energy Ignition project (June 1998), there is a section titled "High Energy Ignition or CDI?" Here is a line from the text: 'of course, we recommend the Multi-Spark CDI design for 2-stroke and 4-stroke engines in motorbikes, outboards and Go-karts, in racing applications and older cars (pre-1975) which do not have lean mixtures'.

I have a 1968 1500 VW Beetle which comes standard with the most basic of fuel and ignition systems. In the opinion of your designers should I return the HEI and try to source a MS-CDI kit? If so where do I find a MS-CDI kit? (R. D., Auckland, NZ.

● We would definitely not use the CDI with a VW. The long parallel runs of spark plug leads give rise to severe crossfire (we speak from experience here). Build the HEI.

## Weird fault in touch dimmer

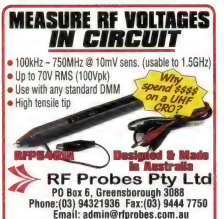
After a long wait, I was finally able to purchase the Touch/Remote Controlled Light Dimmer kit described in January & February 2002. It worked straight away, even the IR part with the remote control from my LG TV. Then it started to do something strange.

If I tapped the panel twice, it would go to full brightness and cut out straight away. If I held my hand on the panel, it would increase the light slowly, but when it reached full power it would turn off; the same thing happened with the remote. If I did not get it to full brightness, it was fine.

I went out for a few hours and when I got back the unit would not turn on at all. What now? (P. E., via email).

● We think you need to connect the dimmer up using the low voltage transformer connection shown in Fig.10 of the article. This way you can check operation safely. Check the supply voltage to IC1 for 5V.

Note that your problem seems to lie with the phase control extending into the next half waveform so that the lamp goes out when it should be at full brightness. Is the .01μF near ZD1 the correct value and are the 680kΩ resistors correctly in place.



## Bleed resistors in power amplifier

Just a question about the 100W Ultra-LD Stereo Amplifier featured in the May 2000 edition: On the filter capacitors, there are two 8.2kΩ 1W resistors across the supply rails. Could you please tell me what they do? (C. D., via email).

● They are bleed resistors. They discharge the capacitors in case the supply rails have been disconnected (or the fuses have blown). Without them, the capacitors stay charged for long periods even after the power is turned off and this could be hazardous if you are working on the amplifier.

The same resistors are present in the power supply of the rack case version presented in the November & December 2001 issues.

## Notes & Errata

**Battery Guardian, May 2002:** instead of being listed as 05106021, the PC board should be 05105021. **SC**


## WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely. Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine. Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

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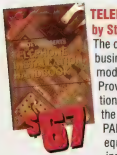

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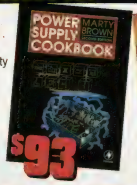

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**July 1989:** Exhaust Gas Monitor; Experimental Mains Hum Sniffers; Compact Ultrasonic Car Alarm; The NSW 86 Class Electrics.

**September 1989:** 2-Chip Portable AM Stereo Radio Pt.1; High Or Low Fluid Level Detector; Studio Series 20-Band Stereo Equaliser, Pt.2.

**October 1989:** FM Radio Intercom For Motorbikes Pt.1: GaAsFet Preamplifier For Amateur TV; 2-Chip Portable AM Stereo Radio, Pt.2.

**November 1989:** Radfax Decoder For Your PC (Displays Fax, RTTY & Morse); FM Radio Intercom For Motorbikes, Pt.2; 2-Chip Portable AM Stereo Radio, Pt.3; Floppy Disk Drive Formats & Options.

**January 1990:** High Quality Sine/Square Oscillator; Service Tips For Your VCR; Phono Patch For Radio Amateurs; Active Antenna Kit; Designing UHF Transmitter Stages.

**February 1990:** A 16-Channel Mixing Desk; Build A High Quality Audio Oscillator, Pt.2; The Incredible Hot Canaries; Random Wire Antenna Tuner For 6 Metres; Phono Patch For Radio Amateurs, Pt.2.

**March 1990:** Delay Unit For Automatic Antennas; Workout Timer For Aerobics Classes; 16-Channel Mixing Desk, Pt.2; Using The UC3906 SLA Battery Charger IC.

**April 1990:** Dual Tracking ±50V Power Supply; Voice-Operated Switch With Delayed Audio; 16-Channel Mixing Desk, Pt.3; Active CW Filter.

**June 1990:** Multi-Sector Home Burglar Alarm; Build A Low-Noise Universal Stereo Preamplifier; Load Protector For Power Supplies.

**July 1990:** Digital Sine/Square Generator, Pt.1 (covers 0-500kHz); Burglar Alarm Keypad & Combination Lock; Build A Simple Electronic Die; A Low-Cost Dual Power Supply.

**August 1990:** High Stability UHF Remote Transmitter; Universal Safety Timer For Mains Appliances (8 Minutes); Horace The Electronic Cricket; Digital Sine/Square Generator, Pt.2.

**September 1990:** A Low-Cost 3-Digit Counter Module; Build A Simple Shortwave Converter For The 2-Metre Band; The Care & Feeding Of Nicad Battery Packs (Getting The Most From Nicad Batteries).

**October 1990:** The Dangers of PCBs; Low-Cost Siren For Burglar Alarms; Dimming Controls For The Discolight; Surfsound Simulator; DC Offset For DMMs; NE602 Converter Circuits.

**November 1990:** Connecting Two TV Sets To One VCR; Build An Egg Timer; Low-Cost Model Train Controller; 1.5V To 9V DC Converter; Introduction To Digital Electronics; A 6-Metre Amateur Transmitter.

**December 1990:** 100W DC-DC Converter For Car Amplifiers; Wiper Pulser For Rear Windows; 4-Digit Combination Lock; 5W Power Amplifier For The 6-Metre Amateur Transmitter; Index To Volume 3.

**January 1991:** Fast Charger For Nicad Batteries, Pt.1; Have Fun With The Fruit Machine (Simple Poker Machine); Build A Two-Tone Alarm Module; The Dangers of Servicing Microwave Ovens.

**March 1991:** Transistor Beta Tester Mk.2; A Synthesised AM Stereo Tuner, Pt.2; Multi-Purpose I/O Board For PC-Compatibles; Universal Wideband RF Preamplifier For Amateur Radio & TV.

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**May 1991:** 13.5V 25A Power Supply For Transceivers; Stereo Audio Expander; Fluorescent Light Simulator For Model Railways; How To Install Multiple TV Outlets, Pt.1.

**July 1991:** Loudspeaker Protector For Stereo Amplifiers; 4-Channel Lighting Desk, Pt.2; How To Install Multiple TV Outlets, Pt.2; Tuning In To Satellite TV, Pt.2.

**September 1991:** Digital Altimeter For Gliders & Ultralights; Ultrasonic Switch For Mains Appliances; The Basics Of A/D & D/A Conversion; Plotting The Course Of Thunderstorms.

**October 1991:** Build A Talking Voltmeter For Your PC, Pt.1; SteamSound Simulator For Model Railways Mk.II; Magnetic Field Strength Meter; Digital Altimeter For Gliders, Pt.2; Military Applications Of R/C Aircraft.

**November 1991:** Colour TV Pattern Generator, Pt.1; A Junkbox 2-Valve Receiver; Flashing Alarm Light For Cars; Digital Altimeter For Gliders, Pt.3; Build A Talking Voltmeter For Your PC, Pt.2.

**December 1991:** TV Transmitter For VCRs With UHF Modulators; Infrared Light Beam Relay; Colour TV Pattern Generator, Pt.2; Index To Volume 4.

**March 1992:** TV Transmitter For VHF VCRs; Thermostatic Switch For Car Radiator Fans; Coping With Damaged Computer Directories; Valve Substitution In Vintage Radios.

**April 1992:** IR Remote Control For Model Railroads; Differential Input Buffer For CROs; Understanding Computer Memory; Aligning Vintage Radio Receivers, Pt.1.

**June 1992:** Multi-Station Headset Intercom, Pt.1; Video Switcher For Camcorders & VCRs; IR Remote Control For Model Railroads, Pt.3; 15-Watt 12-24V Inverter; A Look At Hard Disk Drives.

**October 1992:** 2kW 24VDC - 240VAC Sinewave Inverter; Multi-Sector Home Burglar Alarm, Pt.2; Mini Amplifier For Personal Stereos; A Regulated Lead-Acid Battery Charger.

**February 1993:** Three Projects For Model Railroads; Low Fuel Indicator For Cars; Audio Level/VU Meter (LED Readout); An Electronic Cockroach; 2kW 24VDC To 240VAC Sinewave Inverter, Pt.5.

**March 1993:** Solar Charger For 12V Batteries; Alarm-Triggered Security Camera; Reaction Trainer; Audio Mixer for Camcorders; A 24-Hour Sidereal Clock For Astronomers.

**April 1993:** Solar-Powered Electric Fence; Audio Power Meter; Three-Function Home Weather Station; 12VDC To 70VDC Converter; Digital Clock With Battery Back-Up.

**June 1993:** AM Radio Trainer, Pt.1; Remote Control For The Woofer Stopper; Digital Voltmeter For Cars; Windows-Based Logic Analyser.

**July 1993:** Single Chip Message Recorder; Light Beam Relay Extender; AM Radio Trainer, Pt.2; Quiz Game Adjudicator; Windows-Based Logic Analyser, Pt.2; Antenna Tuners – Why They Are Useful.

**August 1993:** Low-Cost Colour Video Fader; 60-LED Brake Light Array; Microprocessor-Based Sidereal Clock; Satellites & Their Orbits.

**September 1993:** Automatic Nicad Battery Charger/Discharger; Stereo Preamplifier With IR Remote Control, Pt.1; In-Circuit Transistor Tester; +5V to +15V DC Converter; Remote-Controlled Cockroach.

**October 1993:** Courtesy Light Switch-Off Timer For Cars; Wireless Microphone For Musicians; Stereo Preamplifier With IR Remote Control, Pt.2; Electronic Engine Management, Pt.1.

**November 1993:** High Efficiency Inverter For Fluorescent Tubes; Stereo Preamplifier With IR Remote Control, Pt.3; Siren-Sound Generator; Engine Management, Pt.2; Experiments For Games Cards.

**December 1993:** Remote Controller For Garage Doors; Build A LED Stroboscope; Build A 20W Audio Amplifier Module; A 1-Chip Melody Generator; Engine Management, Pt.3; Index To Volume 6.

**January 1994:** 3A 40V Variable Power Supply; Solar Panel Switching Regulator; Printer Status Indicator; Mini Drill Speed Controller; Stepper Motor Controller; Active Filter Design; Engine Management, Pt.4.

**February 1994:** Build A 90-Second Message Recorder; 12-240VAC 200W Inverter; 0.5W Audio Amplifier; 3A 40V Adjustable Power Supply; Engine Management, Pt.5; Airbags In Cars – How They Work.

**March 1994:** Intelligent IR Remote Controller; 50W (LM3876) Audio Amplifier Module; Level Crossing Detector For Model Railways; Voice Activated Switch For FM Microphones; Engine Management, Pt.6.

**April 1994:** Sound & Lights For Model Railway Level Crossings; Discrete Dual Supply Voltage Regulator; Universal Stereo Preamplifier; Digital Weather Tank Gauge; Engine Management, Pt.7.

**May 1994:** Fast Charger For Nicad Batteries; Induction Balance Metal Locator; Multi-Channel Infrared Remote Control; Dual Electronic Dice; Simple Servo Driver Circuits; Engine Management, Pt.8.

**June 1994:** 200W/350W Mosfet Amplifier Module; A Coolant Level Alarm For Your Car; 80-Metre AM/CW Transmitter For Amateurs; Converting Phono Inputs To Line Inputs; PC-Based Nicad Battery Monitor; Engine Management, Pt.9.

**July 1994:** Build A 4-Bay Bow-Tie UHF TV Antenna; PreChamp 2-Transistor Preamplifier; Steam Train Whistle & Diesel Horn Simulator; 6V SLA Battery Charger; Electronic Engine Management, Pt.10.

**August 1994:** High-Power Dimmer For Incandescent Lights; Microprocessor-Controlled Morse Keyer; Dual Diversity Tuner For FM Microphones, Pt.1; Nicad Zapper (For Resurrecting Nicad Batteries); Electronic Engine Management, Pt.11.

**September 1994:** Automatic Discharger For Nicad Battery Packs; Mini/Vox Voice Operated Relay; Image Intensified Night Viewer; AM Radio For Weather Beacons; Dual Diversity Tuner For FM Microphones, Pt.2; Electronic Engine Management, Pt.12.

**October 1994:** How Dolby Surround Sound Works; Dual Rail Variable Power Supply; Build A Talking Headlight Reminder; Electronic Ballast For Fluorescent Lights; Electronic Engine Management, Pt.13.

**November 1994:** Dry Cell Battery Rejuvenator; Novel Alphanumeric Clock; 80-Metre DSB Amateur Transmitter; Twin-Cell Nicad Discharger (See May 1993); How To Plot Patterns Direct to PC Boards.

**December 1994:** Easy-To-Build Car Burglar Alarm; Three-Spot Low Distortion Sinewave Oscillator; Difficult – A Peaky Electronic Cricket; Remote Control System for Models, Pt.1; Index to Vol.7.

**January 1995:** Sun Tracker For Solar Panels; Battery Saver For Torches; Dolby Pro-Logic Surround Sound Decoder, Pt.2; Dual Channel UHF Remote Control; Stereo Microphone Preamplifier.

**February 1995:** 2 x 50W Stereo Amplifier Module; Digital Electes Unit For Musicians; 6-Channel Thermometer With LCD Readout; Wide Range Electrostatic Loudspeakers, Pt.1; Oil Change Timer For Cars; Remote Control System For Models, Pt.2.

**March 1995:** 2 x 50W Stereo Amplifier, Pt.1; Subcarrier Decoder For FM Receivers; Wide-Range Electrostatic Loudspeakers, Pt.2; IR Illuminator For CCD Cameras; Remote Control System For Models, Pt.3.

**April 1995:** FM Radio Trainer, Pt.1; Photographic Timer For Darkrooms; Balanced Microphone Preamp, & Line Filter; 50W/Channel Stereo Amplifier, Pt.2; Wide Range Electrostatic Loudspeakers, Pt.3; 8-Channel Decoder For Radio Remote Control.

**May 1995:** Build A Guitar Headphone Amplifier; FM Radio Trainer, Pt.2; Transistor/Mosfet Tester For DMMs; A 16-Channel Decoder For Radio Remote Control; Introduction to Satellite TV.

**June 1995:** Build A Satellite TV Receiver; Train Detector For Model Railways; 1W Audio Amplifier Trainer; Low-Cost Video Security System; Multi-Channel Radio Control Transmitter For Models, Pt.1.

**July 1995:** Electric Fence Controller; How To Run Two Trains On A Single Track (Incl. Lights & Sound); Setting Up A Satellite TV Ground Station; Build A Reliable Door Minder.

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**December 1995:** Engine Immobiliser; 5-Band Equaliser; CB Transverter For The 80M Amateur Band, Pt.2; Subwoofer Controller; Knock Sensing In Cars; Index To Volume 8.

**January 1996:** Surround Sound Mixer & Decoder, Pt.1; Magnetic Card Reader; Build An Automatic Sprinkler Controller; IR Remote Control For The Ralliopower Mk.2; Recharging Nicad Batteries For Long Life.

**April 1996:** Cheap Battery Refills For Mobile Phones; 125W Audio Amplifier Module; Knock Indicator For Leaded Petrol Engines; Multi-Channel Radio Control Transmitter, Pt.3.

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**December 1996:** Active Filter Cleans Up Your CW Reception; A Fast Clock For Railway Modellers; Low Cost Radio & Electronic Target; Build A Sound Level Meter; 8-Channel Stereo Mixer, Pt.2; Index To Vol.9.

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**April 1997:** Simple Timer With No ICs, Digital Voltmeter For Cars; Loudspeaker Protector For Stereo Amplifiers; Model Train Controller; A Look At Signal Tracing, Pt.1; Cathode Ray Oscilloscopes, Pt.8.

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**January 1998:** Build Your Own 4-Channel Lightshow, Pt.1 (runs off 12VDC or 12VAC); Command Control System For Model Railways, Pt.1; Pan Controller For CCD Cameras.

**February 1998:** Multi-Purpose Fast Battery Charger, Pt.1; Telephone Exchange Simulator For Testing; Command Control System For Model Railways, Pt.2; Build Your Own 4-Channel Lightshow, Pt.2.

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**September 1998:** Troubleshooting Your PC, Pt.5; A Blocked Air-Filter Alarm; Wav-Mag Plus For Digital Jacob's Ladder; Gear Change Indicator For Cars; Capacity Indicator For Rechargeable Batteries.

**October 1998:** Lab Quality AC Millivoltmeter, Pt.1; PC-Controlled Stress-O-Meter; Versatile Electronic Guitar Limiter; 12V Trickle Charger For Float Conditions; Adding An External Battery Pack To Your Flashgun.

**November 1998:** The Christmas Star; A Turbo Timer For Cars; Build A Poker Machine, Pt.1; FM Transmitter For Musicians; Lab Quality AC Millivoltmeter, Pt.2; Improving AM Radio Reception, Pt.1.

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**December 1999:** Solar Panel Regulator; PC Powerhouse (gives +12V, +9V, +5V & -5V rails); Ethernet Primer Metal Locator; Speed Alarm For Cars, Pt.2; Rallipower Model Train Controller, Pt.3; Index To Vol.12.

**January 2000:** Spring Reverberation Module; An Audio-Video Test Generator; Build The Phone Programmable Radio; A Parallel Port Interface Card; Off-Hook Indicator For Telephone Lines.

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**January 2001:** How To Transfer LPs & Tapes To CD; The LP Doctor – Clean Up Clicks & Pops, Pt.1; Arbitrary Waveform Generator; 2-Channel Guitar Preamplifier, Pt.3; PIC Programmer & Testbed.

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**May 2002:** PIC-Controlled 32-LED Knightrider; The Battery Guardian (Cuts Power When the Battery Voltage Drops); A Stereo Headphone Amplifier; Automatic Single-Channel Light Dimmer; Pt.2; Stepper Motor Controller; Shark Shield – Keeping The Man-Eaters At Bay.

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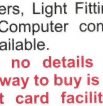

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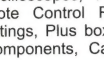

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